HIGH-END COMPUTING CAPABILITY PORTFOLIO

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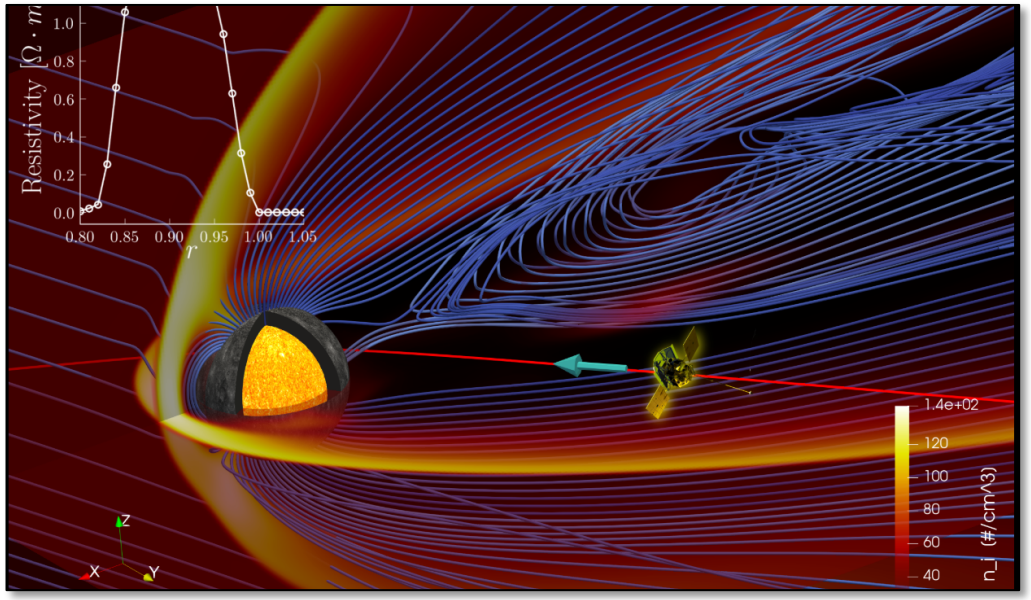
HECC Supercomputer Usage Sets New Normalized Record in April 2020

- In April, the normalized combined usage of HECC supercomputers set a new normalized record of 9,677,882 Standard Billing Units (SBUs).*
- The usage by 322 of NASA's science and engineering groups exceeded the previous record of 9,514,841 SBUs set in February 2020 by 163,041 SBUs (2%).
- The record was achieved in great part by the Science Mission Directorate's Planetary Science for their Integration of Extended Magnetohydrodynamic and Kinetic Effects in Global Magnetosphere Models project and the Earth Science's Subseasonal to Decadal Climate Forecasts project.
- Usage of Pleiades, Electra, Merope, and Endeavour contributed to this record.
- The top 10 projects' usage ranged between 193,462 and 1,174,610 SBUs, and together accounted for over 42% of the total usage.
- The HECC Project continues to evaluate and plan resources to address the future requirements of NASA's users.

** 1 SBU represents the work that can be done in 1 hour on a Pleiades Broadwell 28-core node.*

IMPACT: The increased capacity of HECC systems and working with users to optimize their run capacities provides mission directorates with more resources to accomplish their goals and objectives.



The largest usage was for Mercury's 3D magnetosphere from a novel ten-moment multifluid simulation. The red line together with a cyan arrow represents the trajectory of the MESSENGER spacecraft. *Chuanfei Dong, Liang Wang, Princeton University*

New Chillers Improve N233A Power Usage Effectiveness

- Two chillers were installed at Ames Building N233A in September 2019 to provide cooling for the Merope supercomputer.
  - The new chillers replaced two existing 20-year-old chillers that had failed.
  - The new air-cooled chillers utilize energy efficient rotary scroll compressors and variable-speed condenser fans.
- The new chillers improved the N233A power usage effectiveness (PUE) in FY20 Q2 to 1.37, compared to the FY19 Q2 PUE of 1.50.
  - PUE, an established metric for computer center power efficiency, is calculated as the (Total Facility Power) / (IT Systems Power).
- The new chillers provide a more robust cooling system for Merope that improves the system's availability to the HECC user community and saves significant energy and thus reduces HECC expenses. The energy savings attributed to the new chillers reduces electricity usage by 150,000 kilowatt hours during Q2. When annualized, the energy cost savings will be $44,000 per year.
- The energy savings provided by the new chillers allows for more HECC funds to be spent on compute and storage resources.

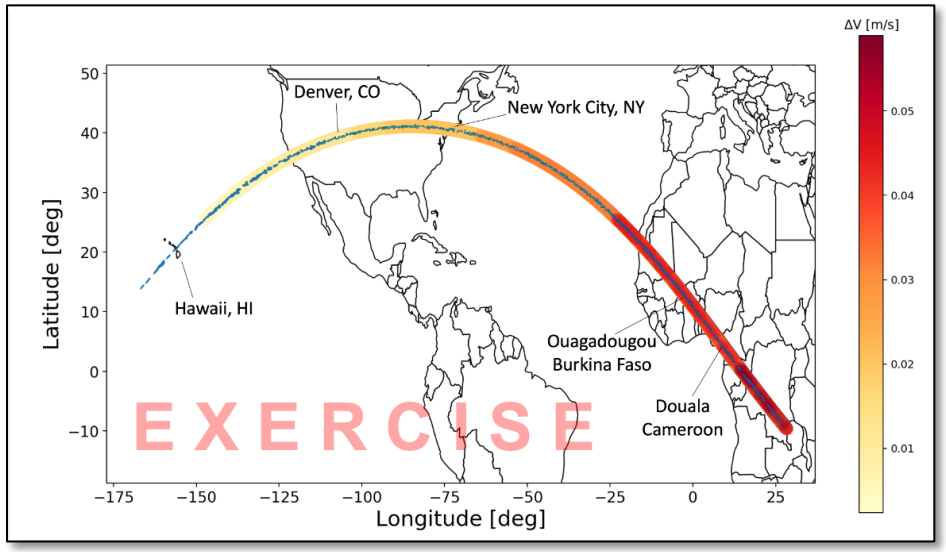
IMPACT: The new chillers save $44,000 per year in energy costs over existing chillers while maintaining a robust cooling system crucial for continuous operation of supercomputing resources for HECC users.

Two new 90-ton chillers installed on the equipment pad at Building N233A at NASA's Ames Research Center supply chilled water to the Merope supercomputer and provide substantial energy savings.
Chris Tanner, NASA/Ames

APP Team Improves Workflow in Asteroid Impact Study

- HECC's Applications Performance and Productivity (APP) team helped remove a performance bottleneck in a python code used by members of NASA's Asteroid Threat Assessment Project (ATAP) group, which resulted in a 150 times speed-up.
- The application is used in risk assessment of asteroids that could impact the Earth. An important aspect of this assessment is that it is possible to change the trajectory of a threatening asteroid by means of a space mission. The modeling of these deflection missions also provides information on the overall risk to human life in a given impact scenario.
- The python application was showing poor scalability with increasing numbers of nodes prior to implementing the solution provided by APP.
  - The bottleneck was caused by multiple python processes opening and closing 1,600 files concurrently, multiple times a second, and causing extreme contention on the Lustre filesystem's metadata servers (mds).
  - The solution was to copy the files to the memory-mapped /tmp directory on each of 80 Ivy Bridge nodes to avoid contention on the mds and do all the I/O out of /tmp at memory speeds, which are orders of magnitude faster than I/O out of Lustre.

IMPACT: Improving job efficiencies for scientists and engineers removes roadblocks and reduces contention on shared resources, and frees up compute resources for the huge, persistent backlog of jobs waiting in the queues.

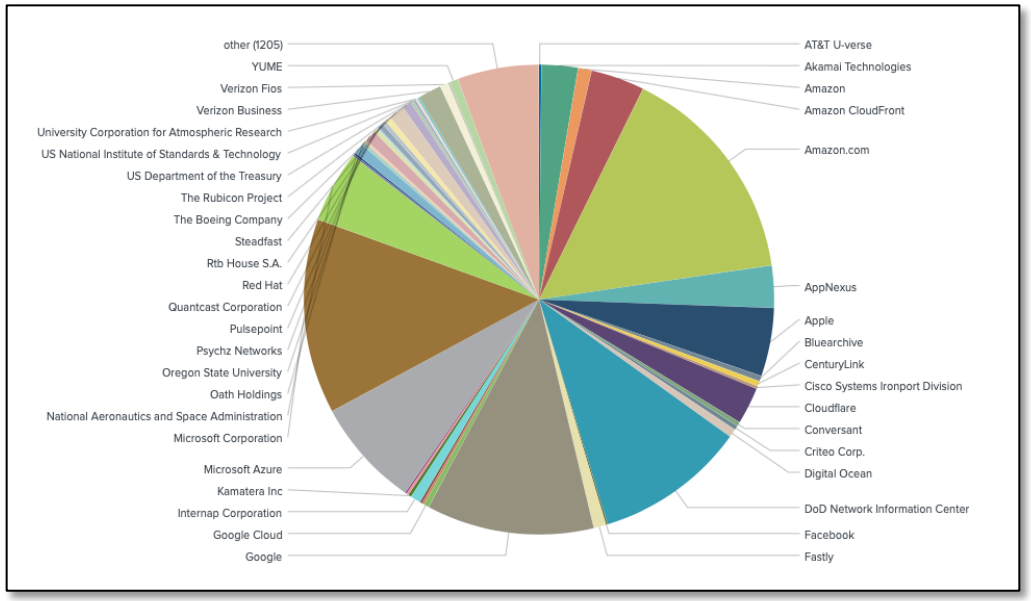


Impact corridor showing the potential impact locations for a synthetic asteroid impact exercise stretching from Hawaii over the U.S. to Africa. Small blue dots show the original impact locations without a deflection mission. The new impact regions under the influence of a deflection mission are color coded according to the deflection impulse imparted on the asteroid in meters per second.
Clemens Rumpf, NASA/Ames

New DNS Analysis Capabilities Improve HECC Security Monitoring System

- HECC security experts added new capabilities to the HECC security monitoring system. Capabilities include:
  - Domain Name System (DNS) statistics, including error code frequency, top failed lookups, top successful lookup, and top requestors.
  - DNS alerts for known malicious domains and suspicious DNS activity.
  - Breakdown of DNS activity by networks, subnets, and hosts.
- These increased capabilities provide the Security team with greater insight into DNS activity that may indicate insider threat activity, data exfiltration, and signs of malware.
- Future work is planned to add additional capacities, including:
  - Creating a fully interactive parallel coordinate plot to analyze DNS request and response activity, allowing security analysts to visualize the relationship between the 40 DNS attributes in 16 coordinates.
  - Correlating DNS request with network flow activity.
  - Providing a detailed view of a host's DNS activity for incident response.

IMPACT: New capabilities provide HECC security analysts with a unified tool to analyze Domain Name System traffic, affording better awareness of the threats and risks to HECC resources.

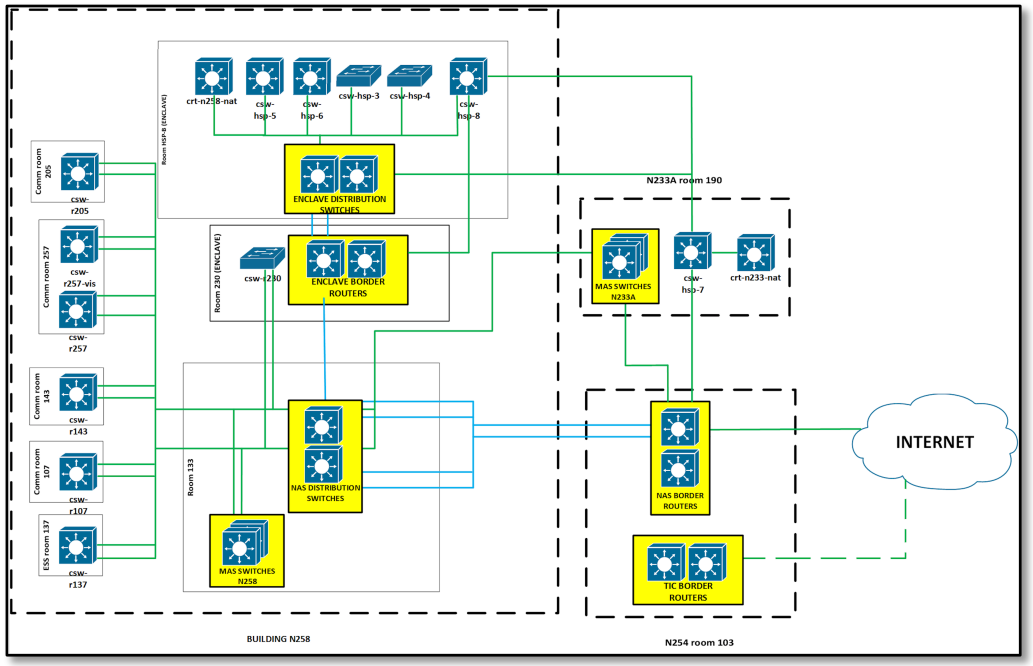


Pie chart created in the NAS Situational Awareness System showing the breakdown of DNS responses by organization for queried domains names.

Networks Team Launches NASLAN Enhancement Project

- The HECC Networks team kicked off a NAS Local Area Network (NASLAN) enhancement project, which will result in the following network upgrades:
  - Remove single points of failure in critical NASLAN equipment by implementing router/switch pairs.
  - Upgrade congested 10-gigabit (G) links to 100G.
  - Replace outdated network equipment.
  - Improve overall network design through optimizations.
- Milestones achieved so far include:
  - Project charter signed.
  - System Requirements Review approved.
  - Design Review approved.
  - Equipment procurement initiated.
- Upcoming project work includes:
  - Complete the implementation plan.
  - Configure and test equipment.
  - Conduct Operational Readiness Reviews as equipment arrives and is configured and tested.

IMPACT: Network upgrades made by the NASLAN enhancement project will improve the uptime, bandwidth and overall performance of the NAS Local Area Network.

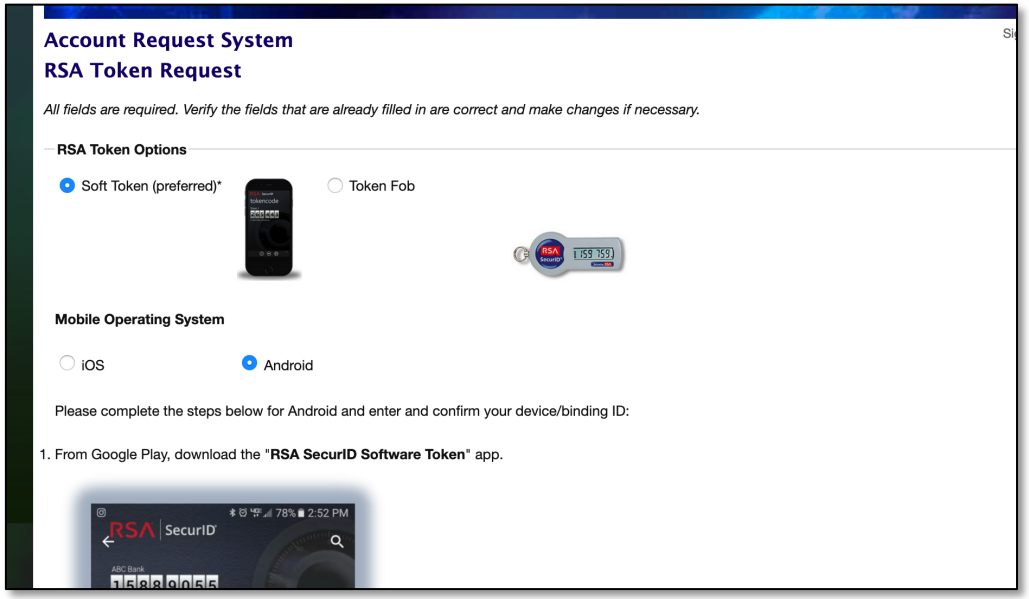


Approved NASLAN network design configuration.

User Services Team Completes Replacement of RSA SecurID Tokens

- The HECC User Services team replaced approximately 344 of 492 RSA hardware tokens that expired on April 30.
  - Only users with active accounts received token expiration notices.
  - Users were encouraged to use the RSA SecurID app, and about one third of replacement tokens issued were software tokens.
  - Software tokens save the HECC project money, as they can be re-assigned and do not have the potential to be lost or damaged in transit.
- User Services staff worked directly with Two-Factor Token Infrastructure administrators to bulk-load replacement token fobs and ensure the activation process for users was seamless.
- Additional coordination with Ames logistics and HECC Property staff ensured that all tokens requested before the deadline were sent out in a timely manner.
- Since tokens for staff could not be picked up on-site due to mandatory telework, User Services coordinated mailing of staff tokens to alternate addresses.
- Many remote users also could not pick up their tokens at their place of employment. User Services worked with these individuals, capturing alternate mailing addresses on the fly, or assisting in the setup of a soft token.

IMPACT: RSA SecurID tokens continue to be the foundation for authenticating to the HECC environment, providing secure access to resources and data; and are especially important for the several hundred users who are PIV-ineligible.



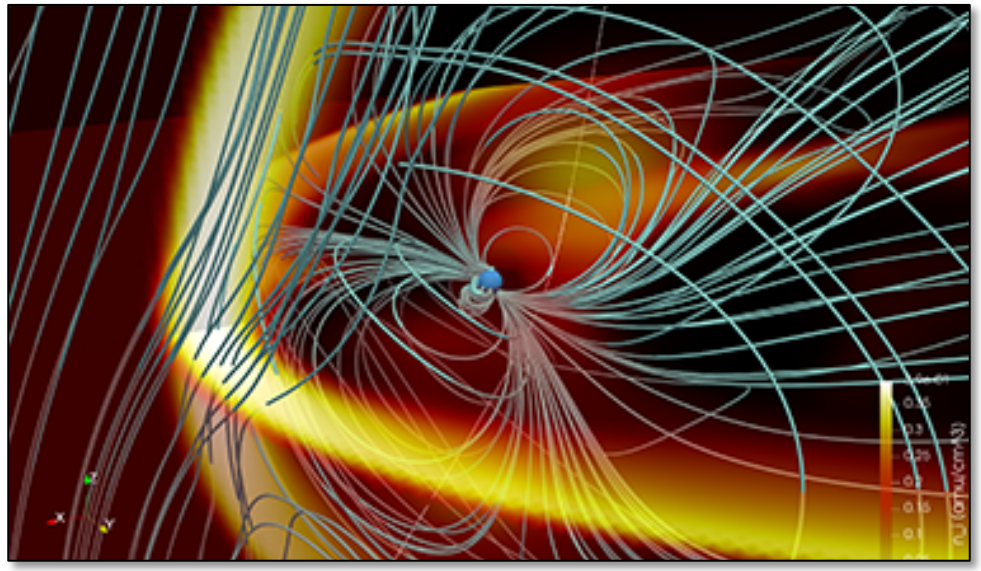
Screenshot of the RSA token replacement web form, which streamlines the replacement process for users and staff.

Simulating Solar Wind Interactions with Mercury, Earth, and Uranus*

- For the first time, researchers at Princeton University performed global (on the scale of many tens of planetary radii) simulations of interactions between the solar wind and planetary magnetospheres, including Mercury, Earth, and Uranus, using a new ten-moment multifluid (multi-ion and single-electron) model.
  - The investigations will enhance the science returns of missions such as MESSENGER to Mercury, Magnetospheric Multiscale around Earth, and the Voyager flyby past Uranus.
- The team uses a 3D magnetosphere model containing key electron physics that are essential to reproduce and interpret the observations.
  - The new model can reproduce observations such as dawn-dusk asymmetries in a planet's magnetotail and field-aligned currents, which cannot be explained by using traditional magnetohydrodynamic approaches.
  - The model is crucial for capturing the electron physics associated with collisionless magnetic reconnection in a planet's magnetosphere.
- Simulation results reveal highly dynamic responses of the planetary magnetospheres to varying external conditions.
- The Pleiades and Electra supercomputers make it possible to perform these 3D high-resolution magnetospheric simulations and study the responses of different planets to varying space weather conditions.

** HECC provided supercomputing resources and services in support of this work.*

IMPACT: Enabled by HECC resources, the investigation of the solar wind interaction with planets under extreme space weather conditions may have important implications for studying (exo)planetary habitability.



View of the Uranian magnetosphere from a ten-moment multifluid simulation. The solar wind impinges from the left and carries inter-planetary magnetic field lines (green streamlines). Yellow contours represent ion number density in unit per cubic centimeter. The boundary in ion density at at left marks the bow shock due to fast-moving solar wind flow. *Chuanfei Dong, Liang Wang, Princeton University*

Predicting High-Altitude Relight in Aircraft Engines*

- Researchers at the University of Michigan ran simulations on Pleiades using their new high-performance computing (HPC) framework, which provides an end-to-end simulation platform to predict high-altitude relight of aircraft engines.
  - Low ambient air pressures and temperatures at high altitude can lead to engine flame-out and hamper relight attempts. In high-altitude relight, an aircraft engine must ignite within a certain period after its initial flameout.
  - Although aircraft fuels are tested to evaluate their ignition characteristics at different operating conditions, it is difficult to experimentally replicate all the physical parameters that affect ignition. Detailed computational models are needed to provide insight into the complex relight process.
- The researchers ran simulations to generate enough samples to represent statistical effects of parameters such as turbulent flow field and initial kernel energy on ignition outcome. Outputs were used to reconstruct ignition probability, using uncertainty quantification.
- Results showed that the modeling framework can efficiently generate abundant high-fidelity data of turbulent forced-ignition processes, which can be applied as input for techniques used to study patterns of altitude relight problems, benefitting future engine design.

** HECC provided supercomputing resources and services in support of this work.*

IMPACT: The ability to re-ignite or relight an aircraft engine at high altitude—critical for safety—is an FAA certification requirement for new aircraft designs. Simulations run on HECC resources help researchers understand the critical physical processes that control ignition.

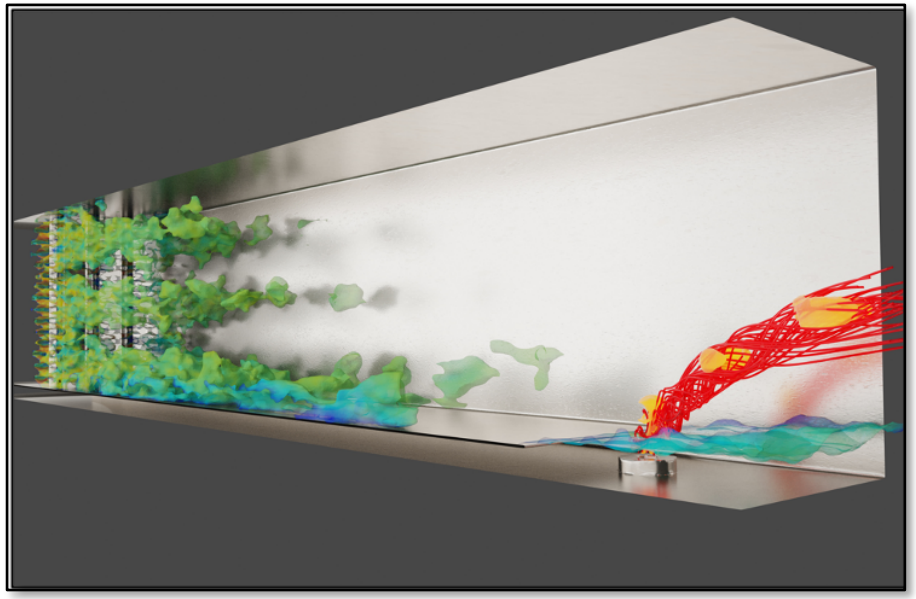


Image of a model aircraft engine combustor that represents high-altitude relight. Shown are upstream fuel mixing (isosurface of mixture fraction colored by velocity magnitude) and downstream non-premixed spark ignition (red lines tracing a spark-induced ignition kernel). *Yihao Tang, Venkat Raman, University of Michigan*

Papers

- "**Revisiting the Sun's Strong Differential Rotation Along Radial Lines**," L. Matilsky, B. Hindman, J. Toomre, arXiv:2004.00208 [astro-ph.SR], April 1, 2020. *
  https://arxiv.org/abs/2004.00208
- "**The Solar-Wind with Hydrogen Ion Exchange and Large-Scale Dynamics (SHIELD) Model: A Self-Consistent Kinetic-MHD Model of the Outer Heliosphere**," A. Michael, et al., arXiv:2004.01152 [physics.space-ph], April 2, 2020. *
  https://arxiv.org/abs/2004.01152
- "**Global Thermodynamic, Transport-Property and Dynamic Characteristics of the Venus Lower Atmosphere Below the Cloud Layer**," S. Morellina, J. Bellancor, J. Cutts, Icarus (pre-print), published online April 9, 2020. *
  https://www.sciencedirect.com/science/article/abs/pii/S0019103520301494
- "**Turning the Exo-Space Weather Radio for Stellar Coronal Mass Ejections**," J. Alvarado-Gómez, et al., arXiv:2004.05379 [astro-ph.SR], April 11, 2020. *
  https://arxiv.org/abs/2004.05379
- "**TOI-1235 b: A Keystone Super-Earth for Testing Radius Valley Emergence Models Around Early M Dwarfs**," R. Cloutier, et al., arXiv:2004.06682 [astro-ph.EP], April 14, 2020. *
  https://arxiv.org/abs/2004.06682
- "**TOI-1338: TESS' First Transiting Circumbinary Planet**," V. Kostov, et al., arXiv:2004.07783 [astro-ph.EP], April 16, 2020. *
  https://arxiv.org/abs/2004.07783

** HECC provided supercomputing resources and services in support of this work*

Papers (cont.)

- "**SCORCH. III. Analytical Models of Reionization with Varying Clumping Factors**," N. Chen, A. Doussot, H. Trac, R. Cen, arXiv:2004.07854 [astro-ph.CO], April 16, 2020. *
  https://arxiv.org/abs/2004.07854
- "**Self-Interacting Dark Matter and the Delay of Super-Massive Black Hole Growth**," A. Cruz, et al., arXiv:2004.08477 [astro-ph.GA], April 17, 2020. *
  https://arxiv.org/abs/2004.08477
- "**Radiometrically Consistent Climate Fingering Using CrIS and AIRS Hyperspectral Observations**," W. Wu, et al., Remote Sensing Special Issue: Analysis of Decadal-Scale Continuous Data Products from Weather Satellite Platforms, published online April 18, 2020. *
  https://www.mdpi.com/2072-4292/12/8/1291
- "**The Multi-Planet System TOI-421 – A Warm Neptune and a Super Puffy Mini-Neptune Transiting a G9 V Star in a Visual Binary**," I. Carleo, et al., arXiv:2004.10095 [astro-ph.EP], April 21, 2020. *
  https://arxiv.org/abs/2004.10095
- "**Robustly Detecting Changes in Warm Jupiters' Transit Impact Parameters**," R. Dawson, The Astronomical Journal, vol. 159, no. 5, April 22, 2020. *
  https://iopscience.iop.org/article/10.3847/1538-3881/ab7fa5/meta

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Papers (cont.)

- "**TESS Discovery of a Super-Earth and Three Sub-Neptunes hosted by the Bright, Sun-like Star HD 108236**," T. Daylan, et al., arXiv:2004.11314 [astro-ph.EP], April 23, 2020. * https://arxiv.org/abs/2004.11314
- "**The TESS-Keck Survey. I. A Warm Sub-Saturn-Mass Planet and a Caution about Stray Light in TESS Cameras**," P. Dalba, et al., The Astronomical Journal, vol. 159, no. 5, April 29, 2020. * https://iopscience.iop.org/article/10.3847/1538-3881/ab84e3

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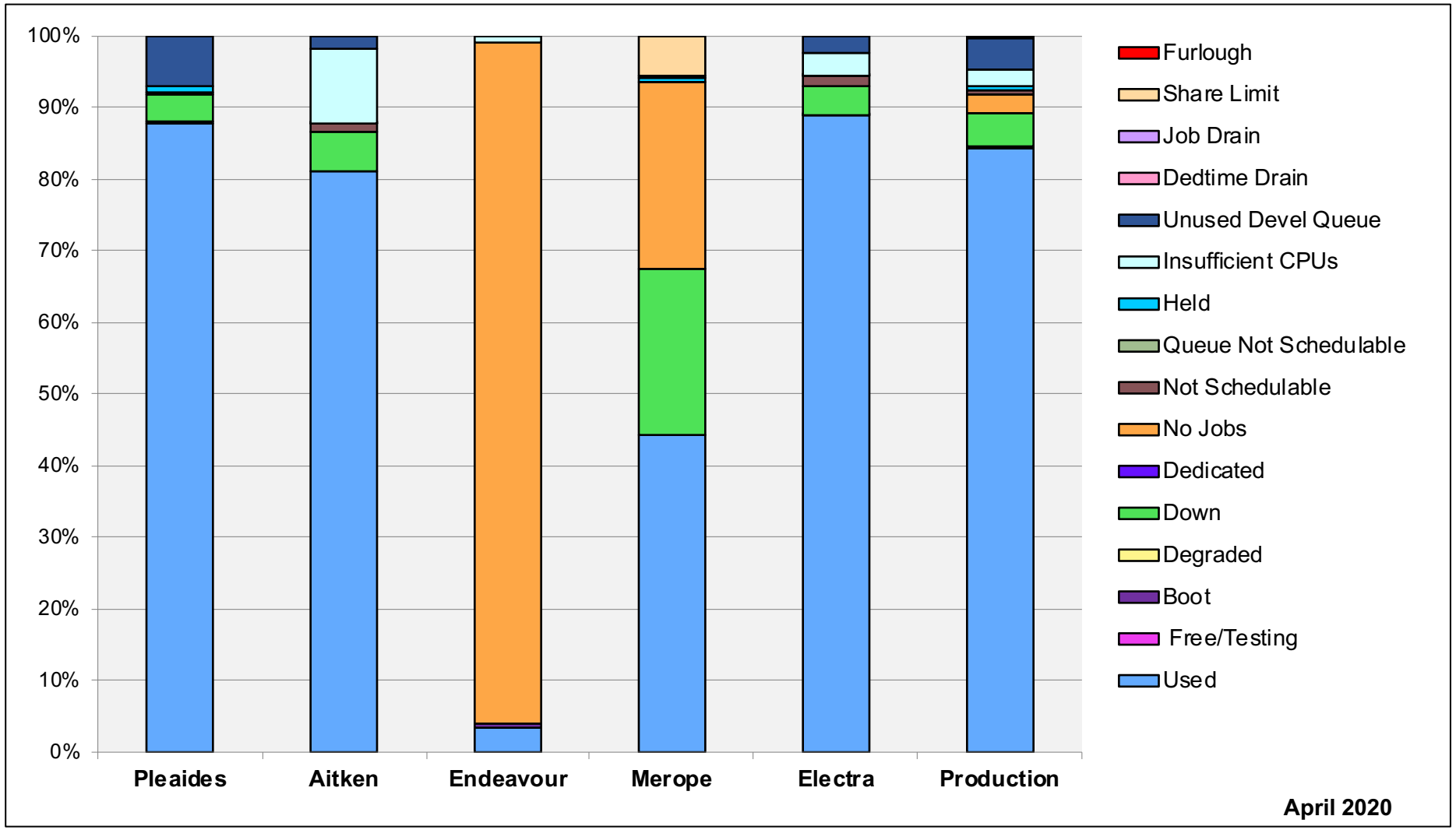
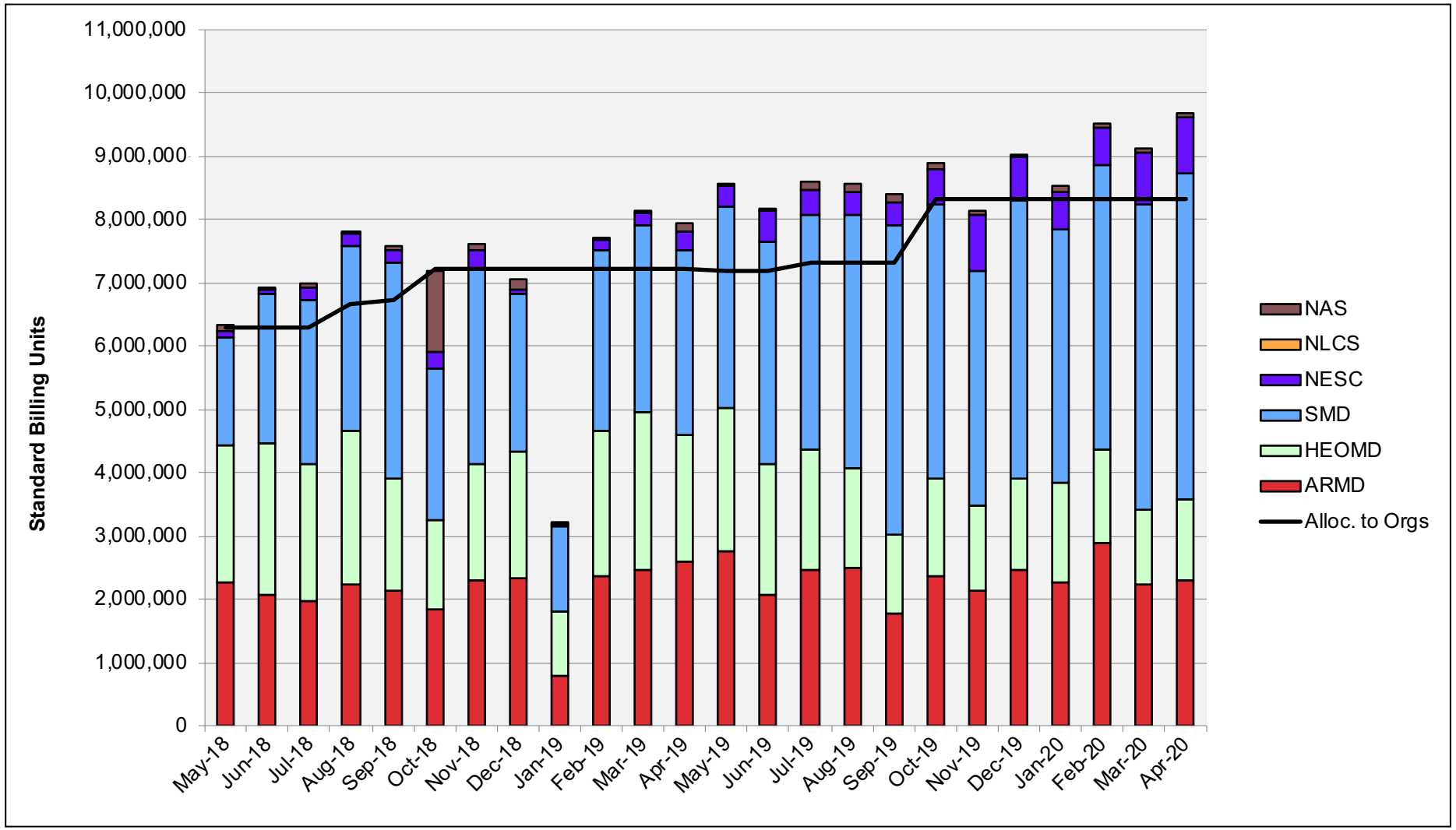
News and Events

- **NASA Calls on Gamers, Citizen Scientists to Help Map World's Corals**, *NASA HQ Release*, April 9, 2020—NASA invites video gamers and citizen scientists to embark on virtual ocean research expeditions to help map coral reefs around the world. Players actions help train NASA's Pleiades supercomputer to recognize corals from any image of the ocean floor, even those taken with less powerful instruments.
  https://www.nasa.gov/press-release/nasa-calls-on-gamers-citizen-scientists-to-help-map-world-s-corals/
  - **NASA Created a Game that Lets You Help Map the Ocean's Coral Reefs**, *CNET*, April 9, 2020.
    https://www.cnet.com/news/nasa-wants-gamers-to-help-it-map-the-oceans-coral-reefs/
  - **Mobile Gamers Help Train NASA Supercomputer to Protect Coral Reefs**, *HPCWire*, April 15, 2020.
    https://www.hpcwire.com/2020/04/15/mobile-gamers-nasa-supercomputer-protect-real-coral-reefs/
  - **Game Generates Training Data for Supercomputer Mapping Coral Reefs,** *GCN,* April 22, 2020.
    https://gcn.com/articles/2020/04/22/nemo-net-coral-mapping.aspx
- **"Tiny Homes" for NASA Supercomputers Suit Silicon Valley's Climate**, *NASA Ames Feature*, April 22, 2020—The same climate that allows California's wine country to grow its famous grapes is also being used by the NASA Advanced Supercomputing Division to cool the high-performance computers of its Modular Supercomputing Facility, saving both energy and water consumption.
  https://www.nasa.gov/feature/ames/tiny-homes-for-nasa-supercomputers-suit-silicon-valley-s-climate

HECC Utilization



HECC Utilization Normalized to 30-Day Month



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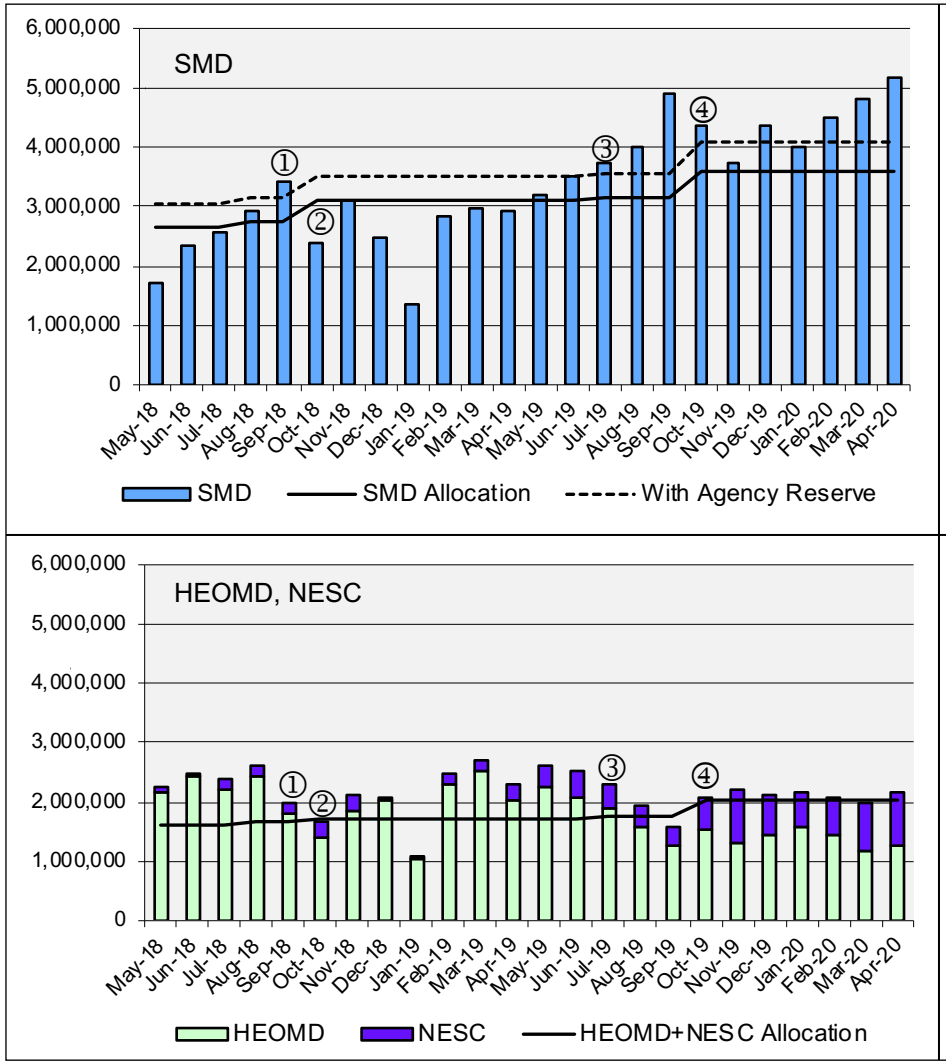
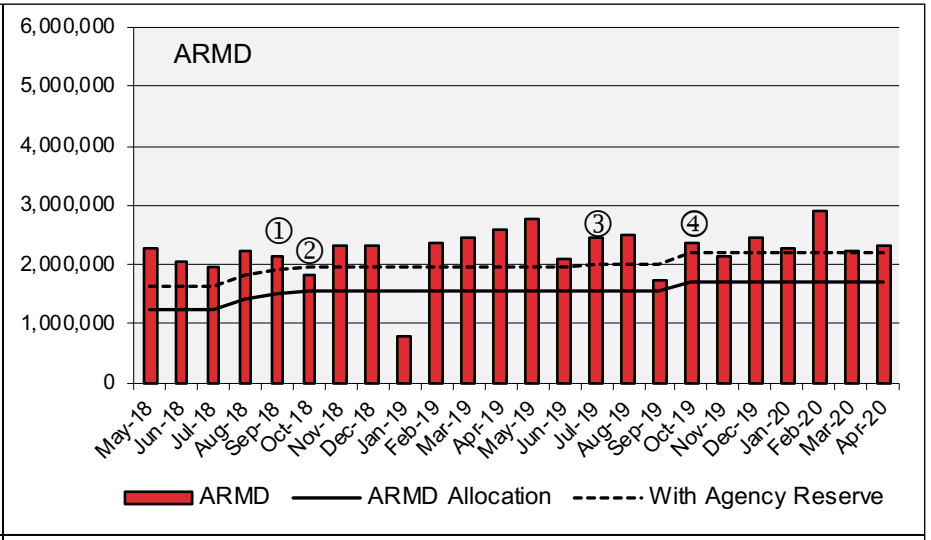




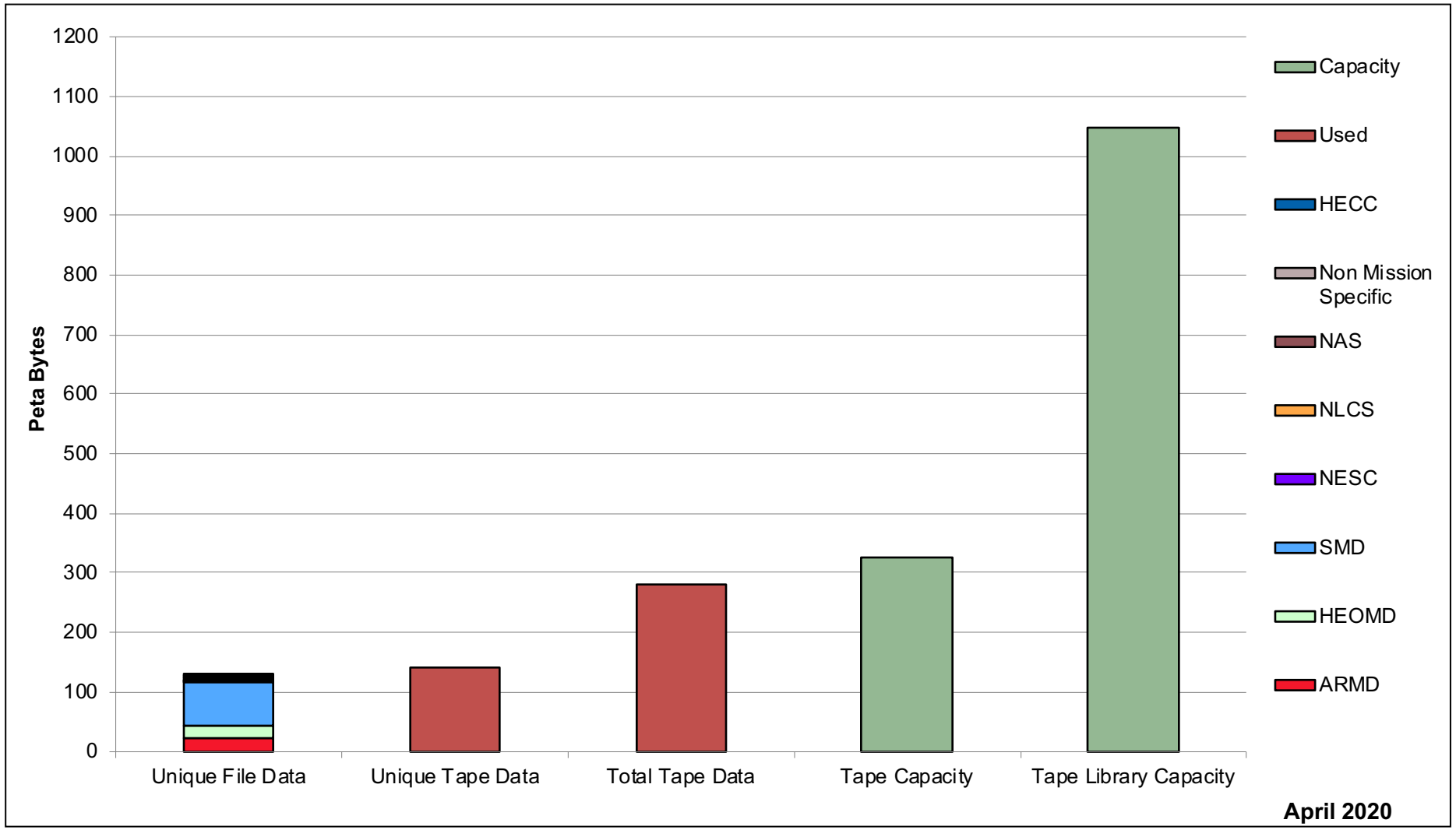
① 4 Skylake E cells (16 D Rack Equivalence) added to Electra

② 2 Skylake E cells (8 D Rack Equivalence) added to Electra; 1 rack is dedicated to ARMD

③ 2 Skylake E cells (8 D Rack Equivalence) added to Electra; 1 rack is dedicated to SMD

④ Skylake Tesla GPU V100 Nodes installed

Tape Archive Status



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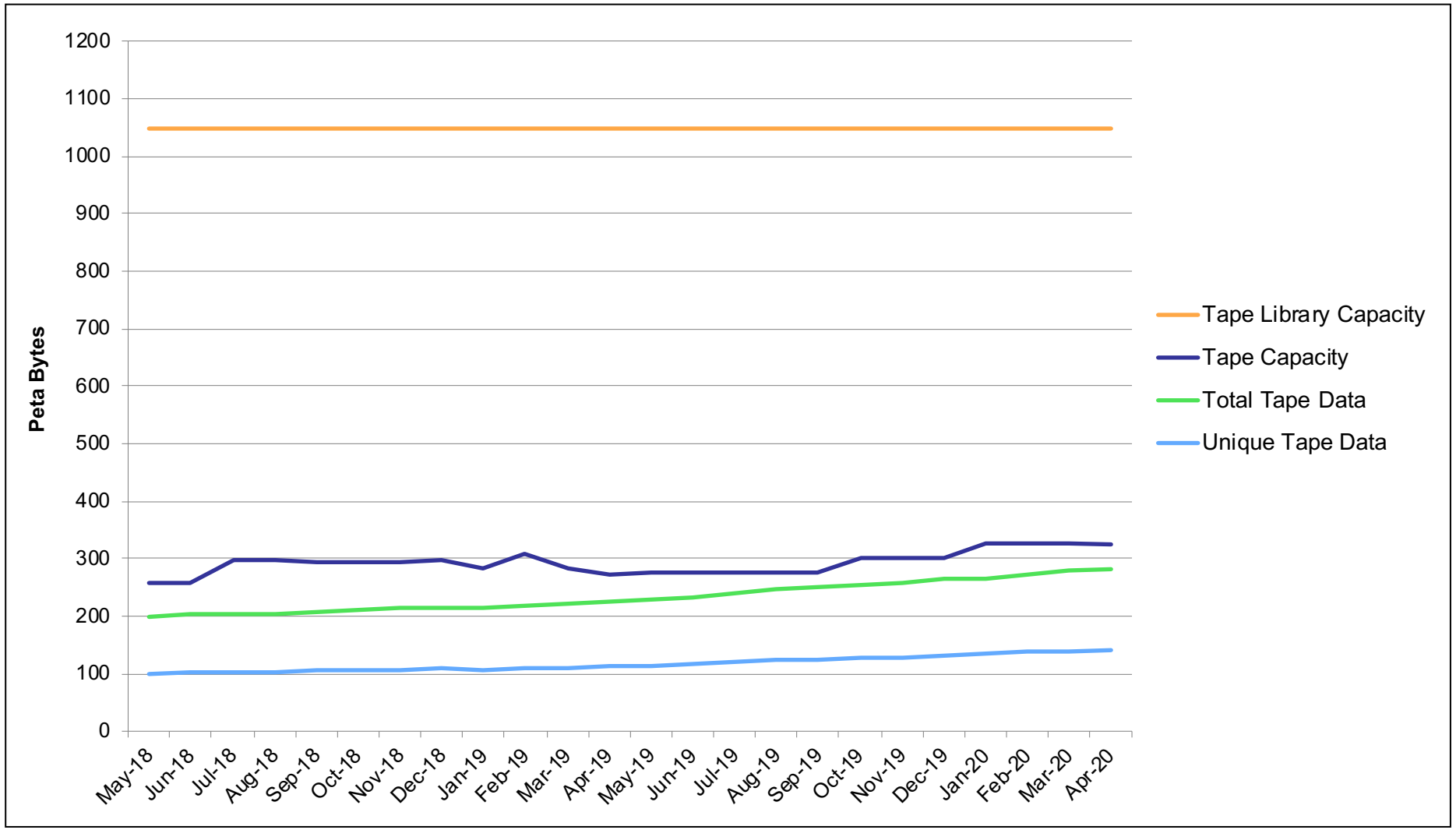
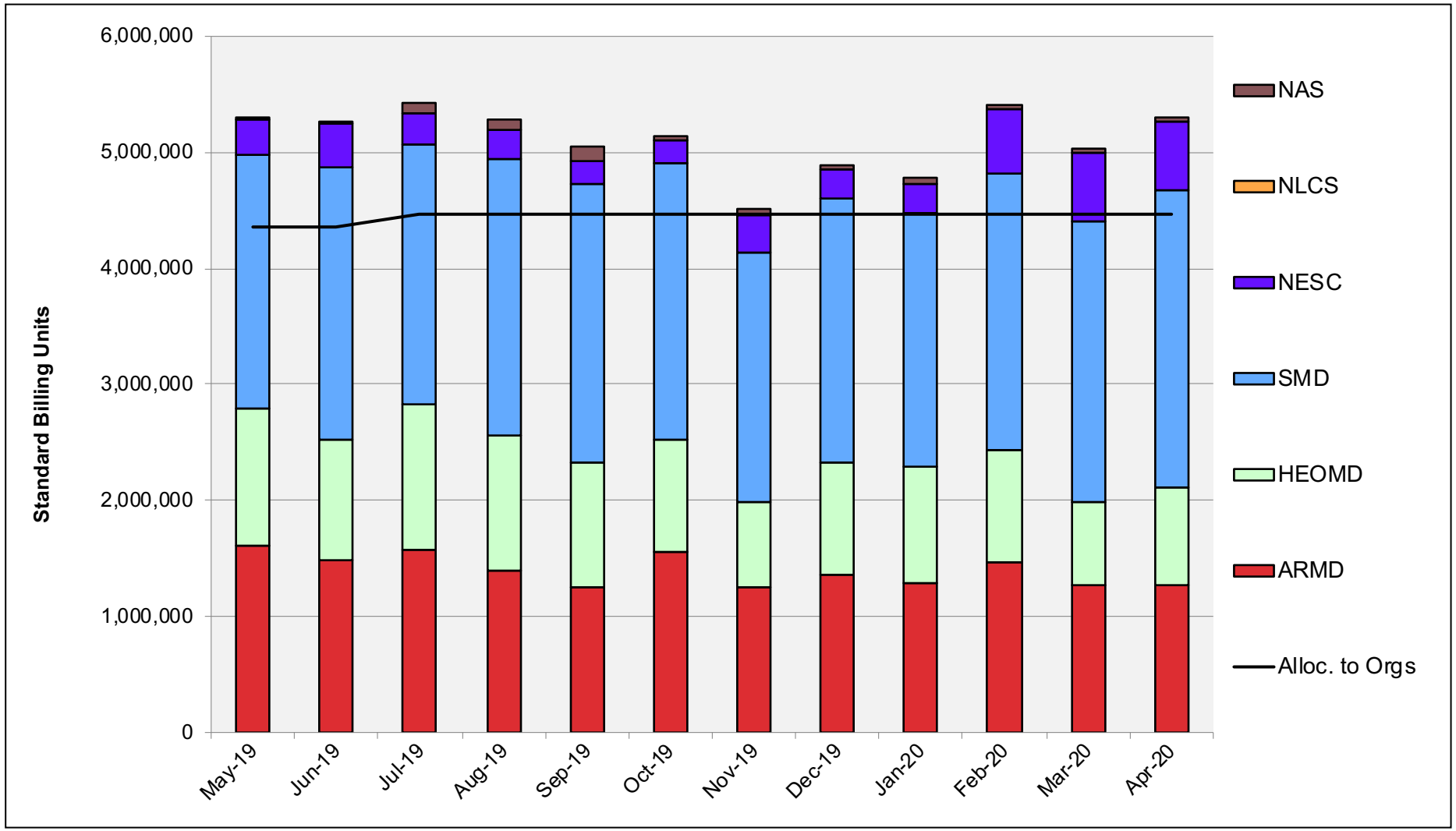
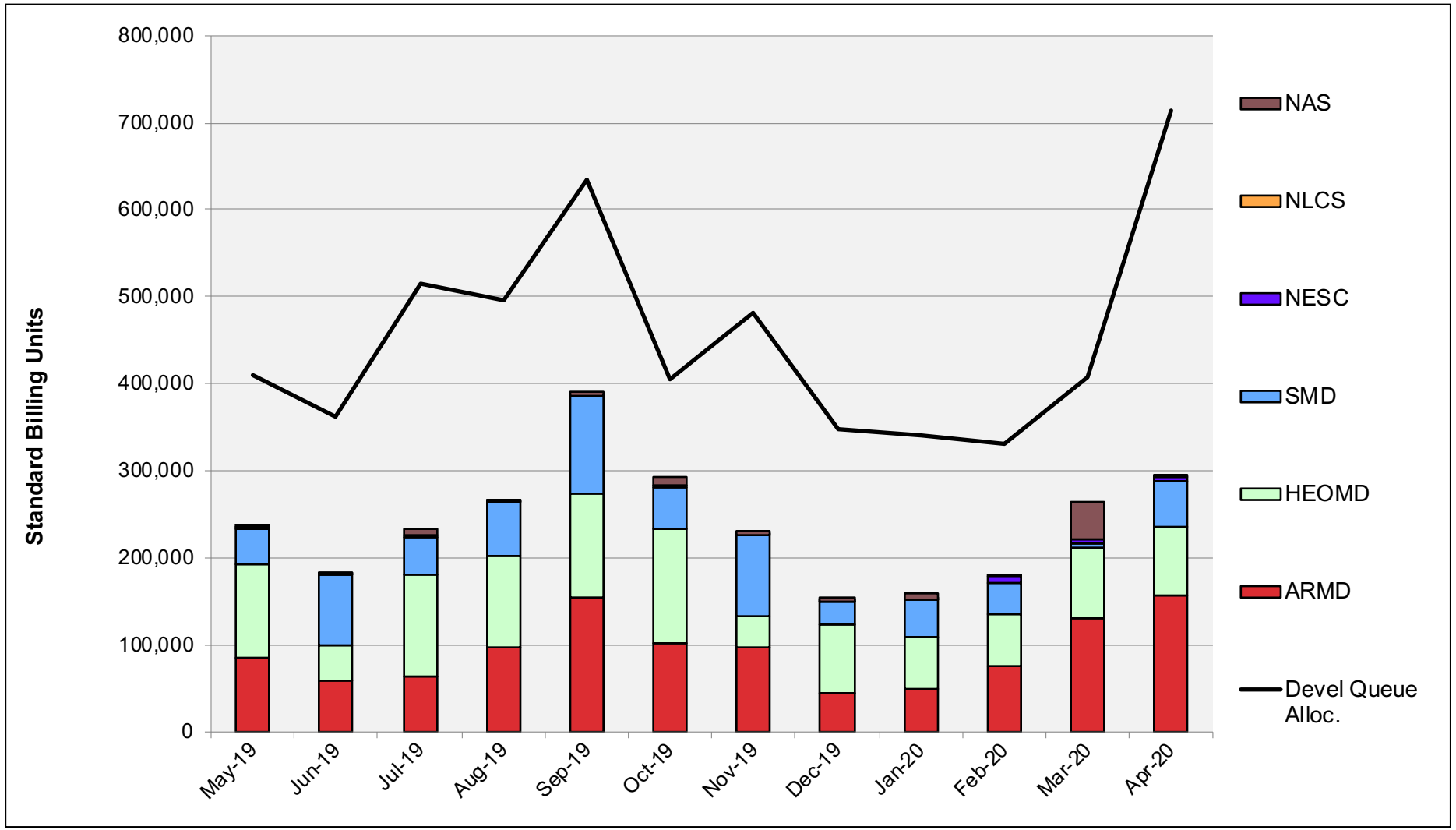


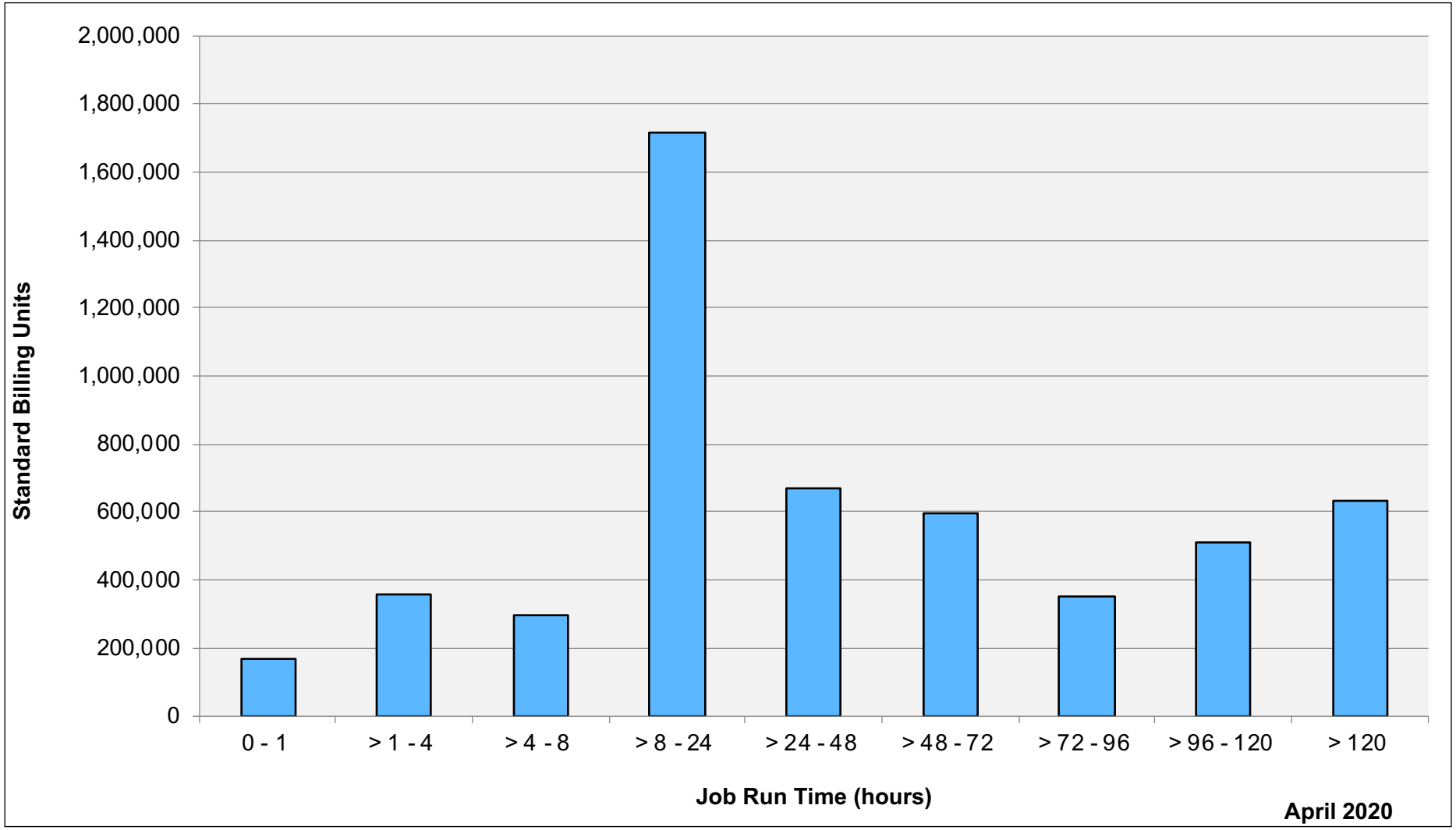
Pleiades: SBUs Reported, Normalized to 30-Day Month



Pleiades: Devel Queue Utilization



Pleiades: Monthly Utilization by Job Length



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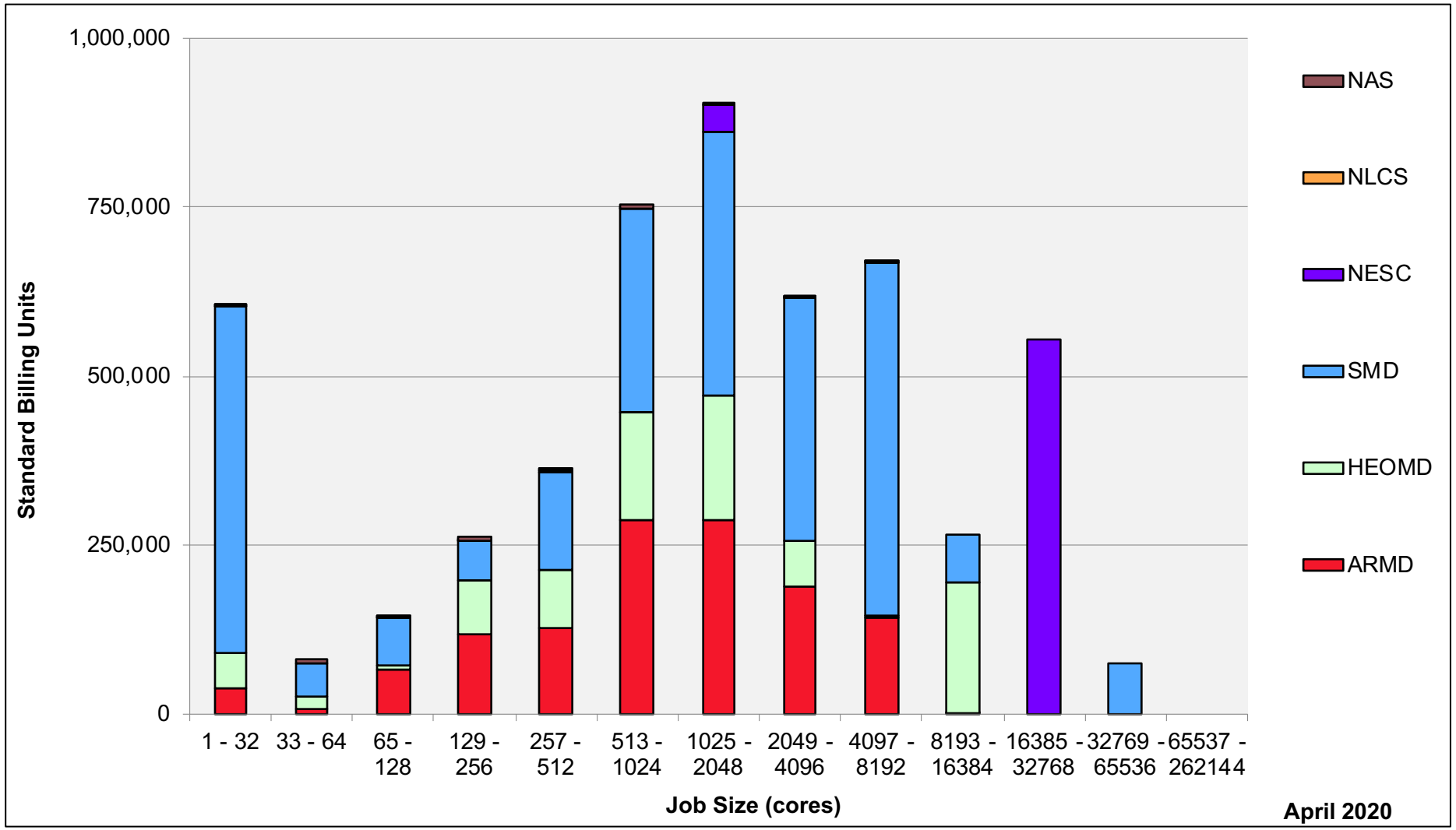
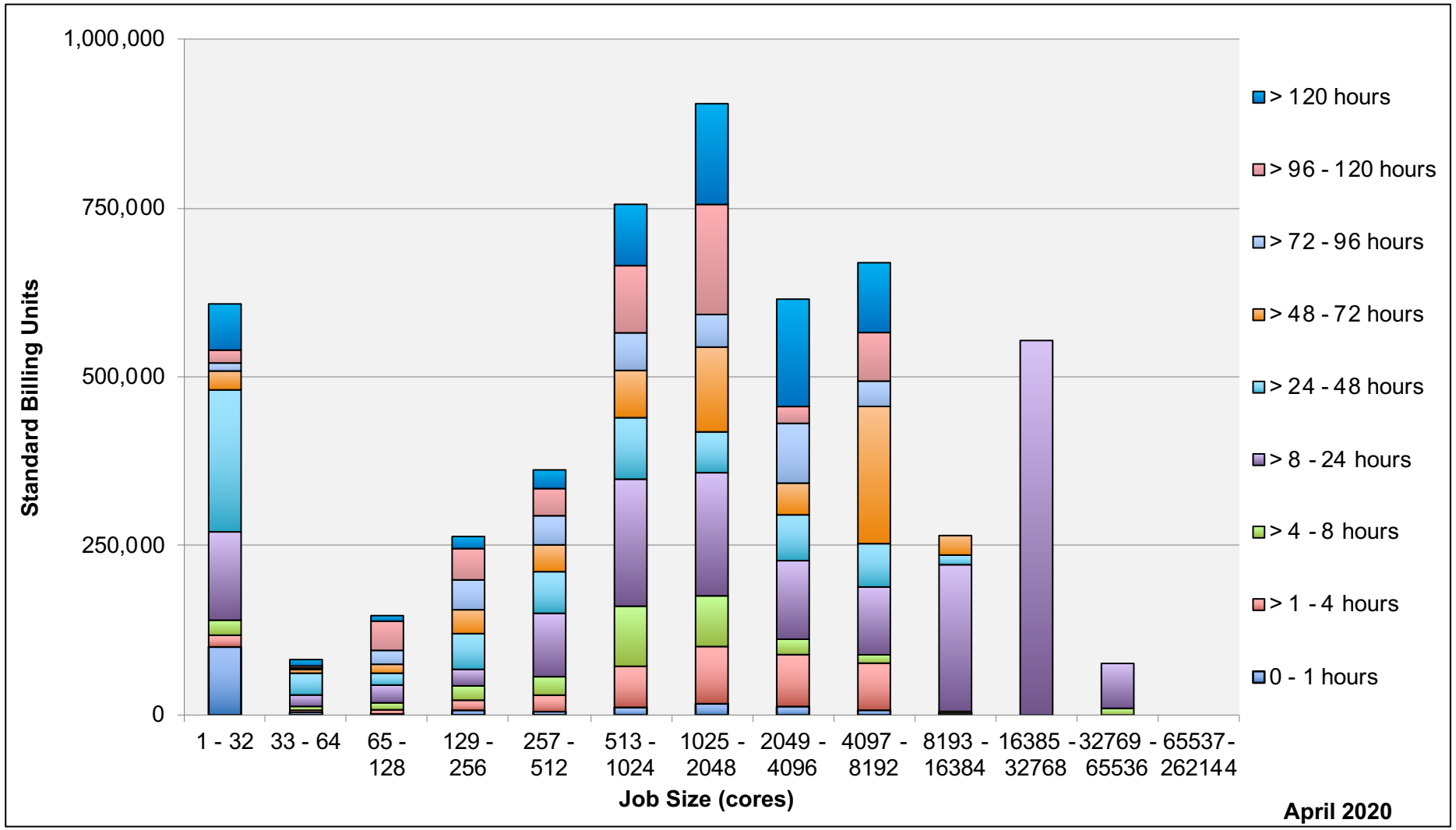
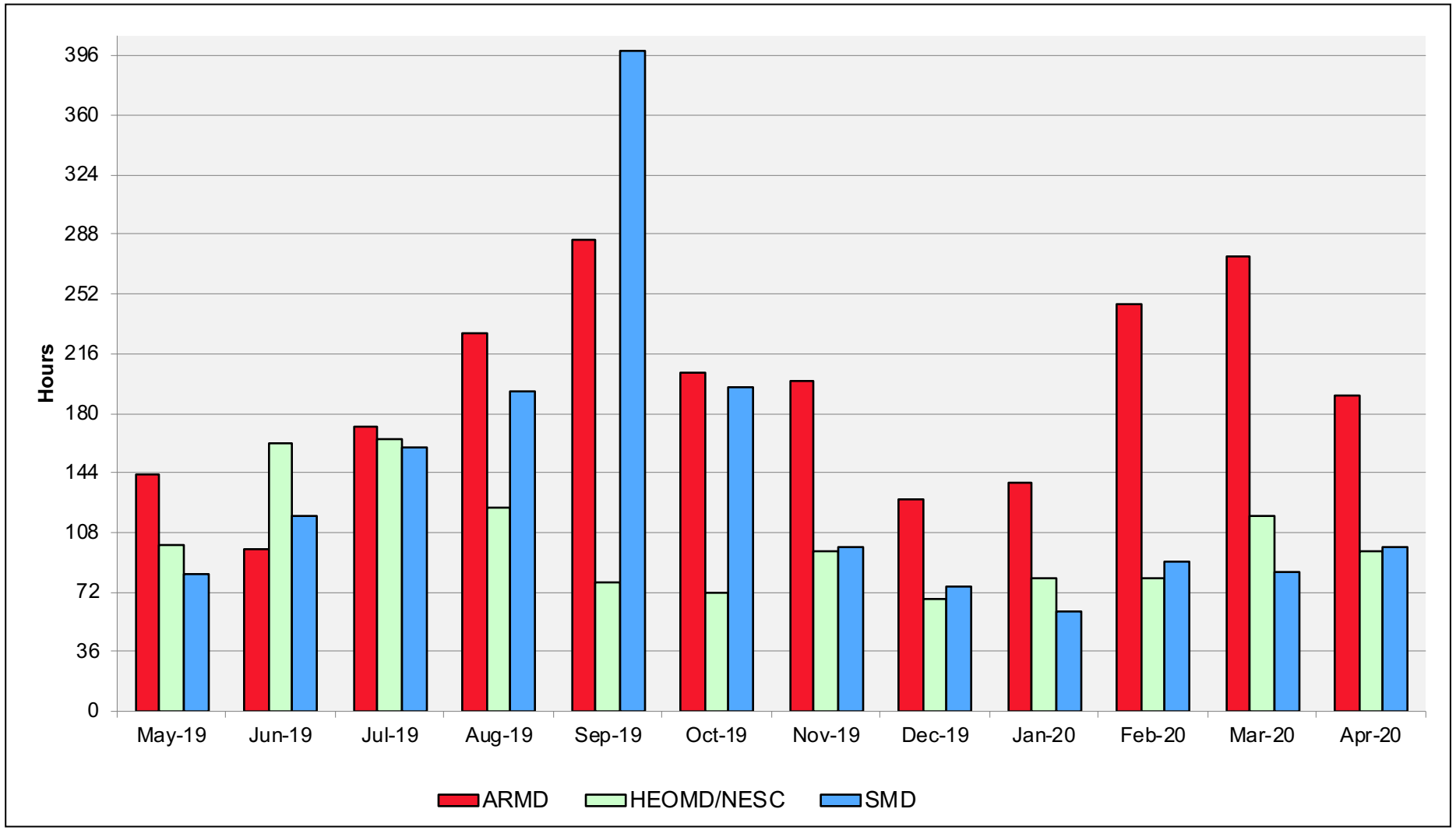


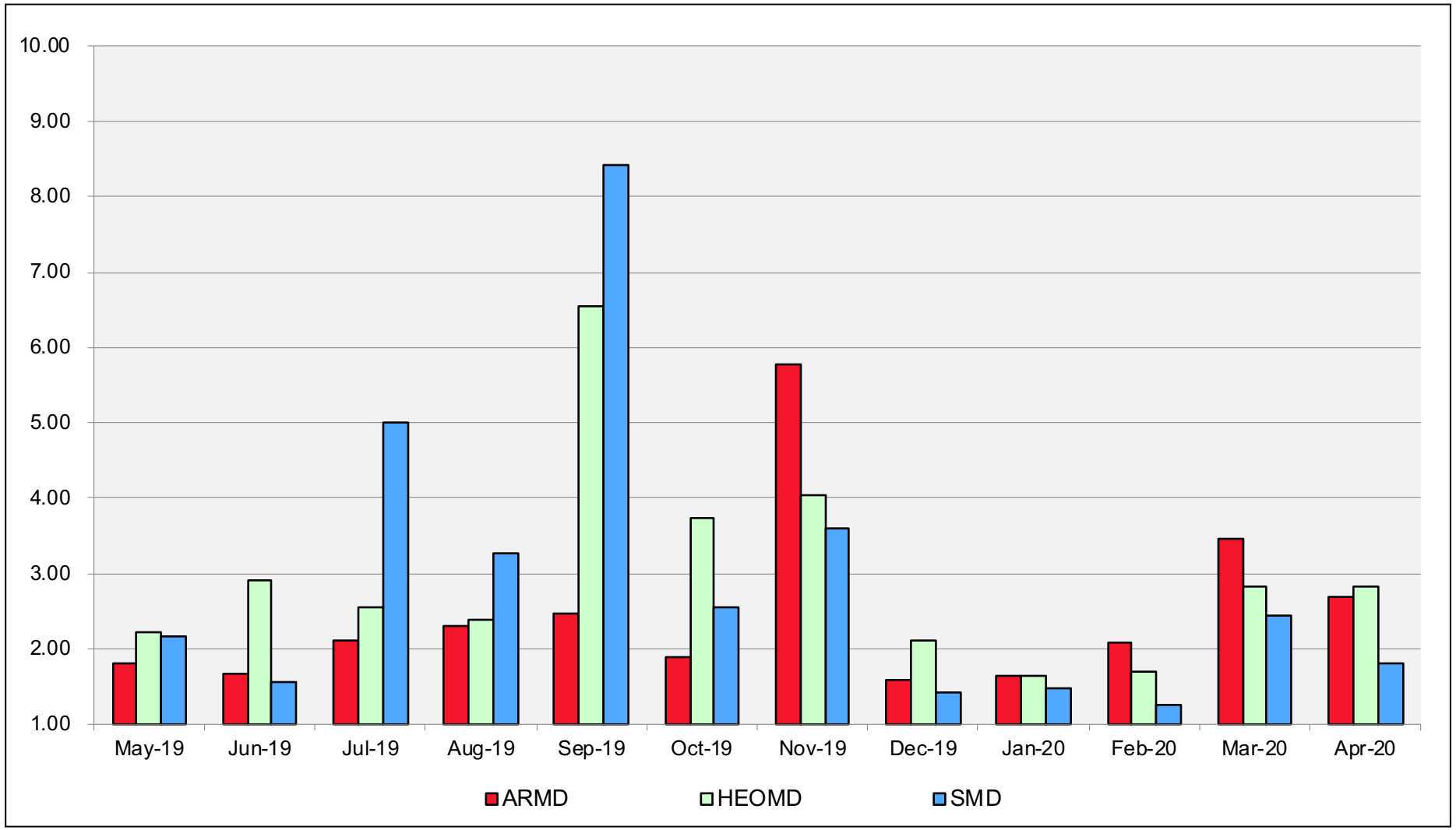
Pleiades: Monthly Utilization by Size and Length



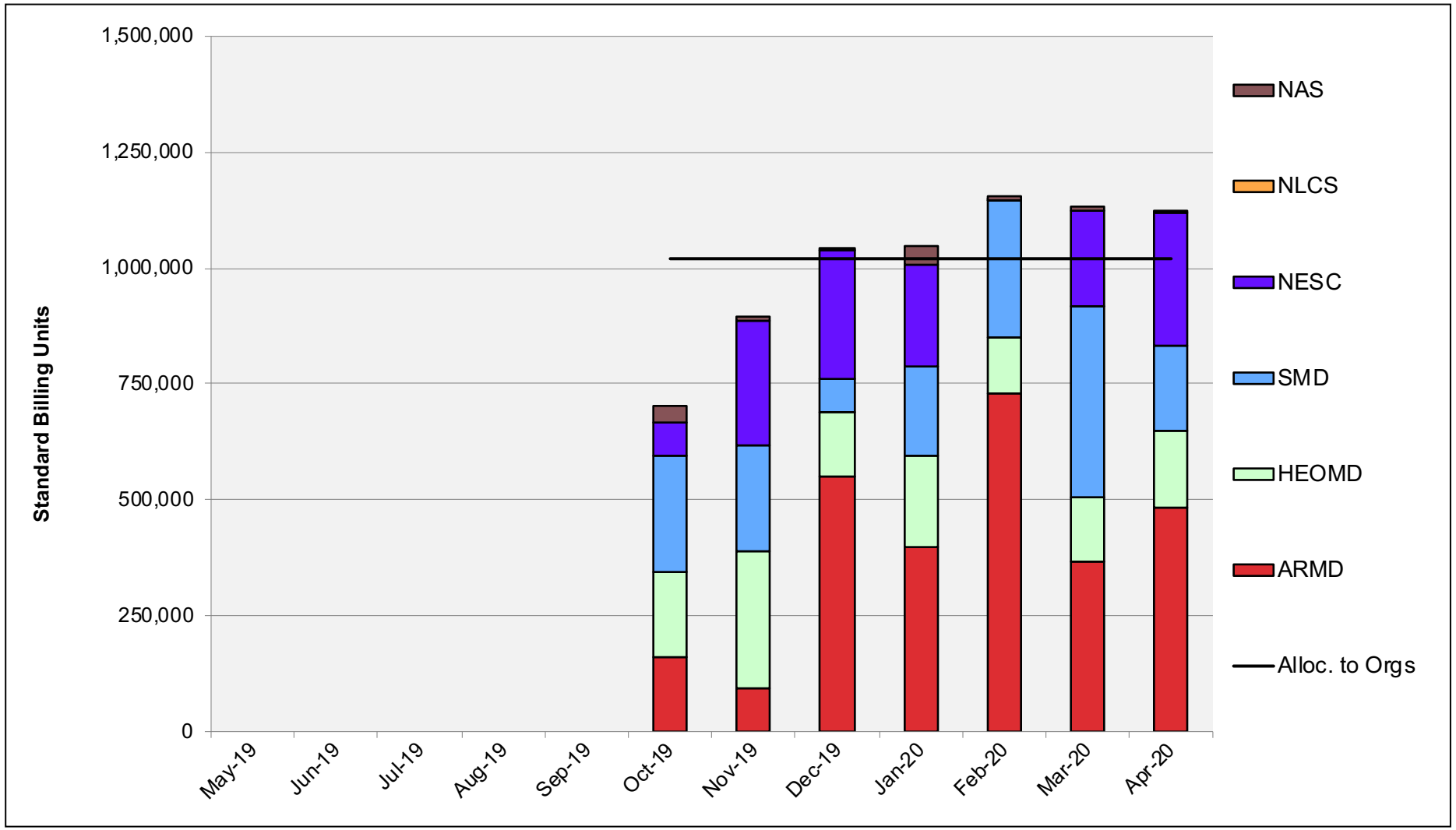
Pleiades: Average Time to Clear All Jobs



Pleiades: Average Expansion Factor



Aitken: SBUs Reported, Normalized to 30-Day Month



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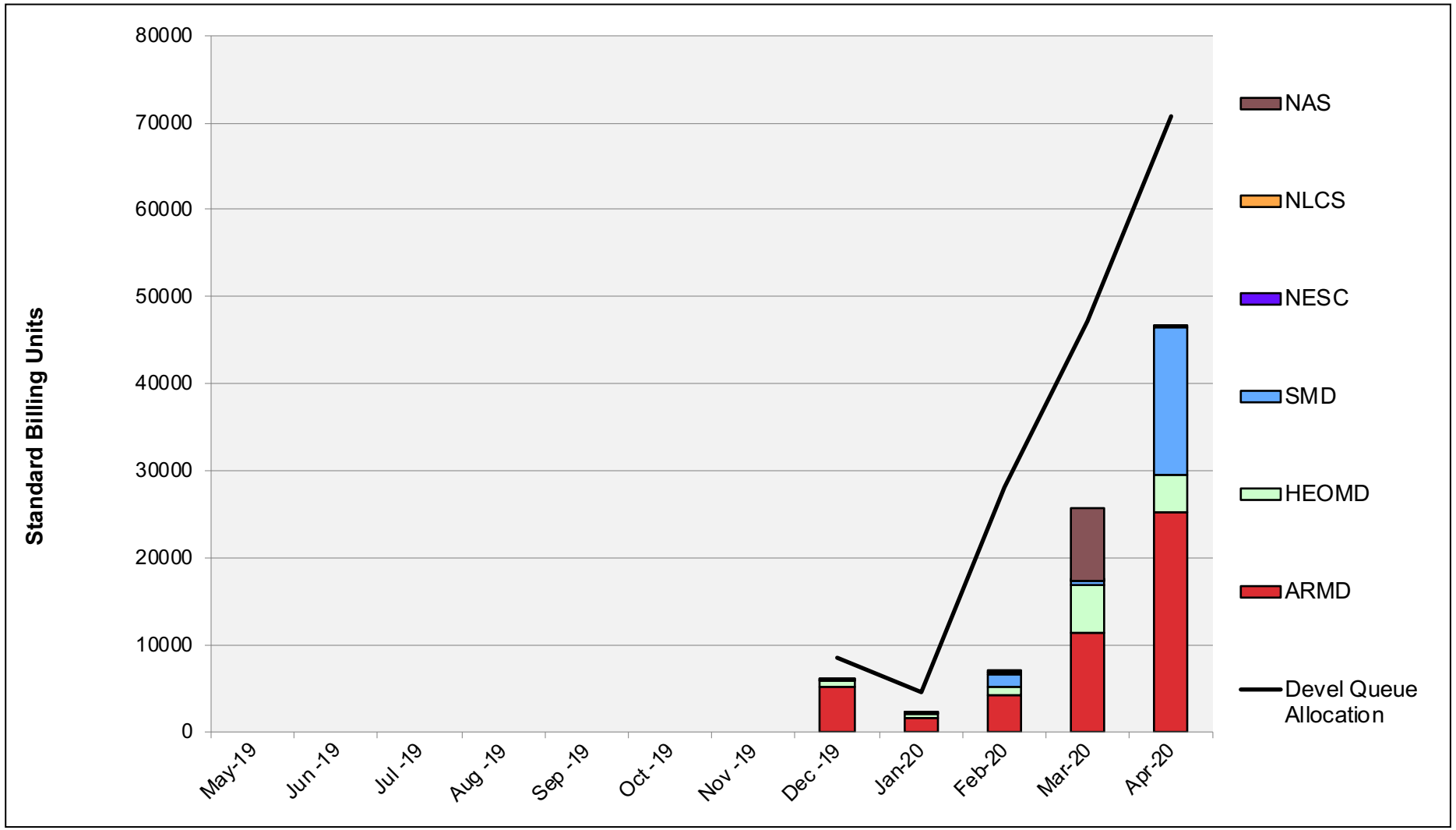

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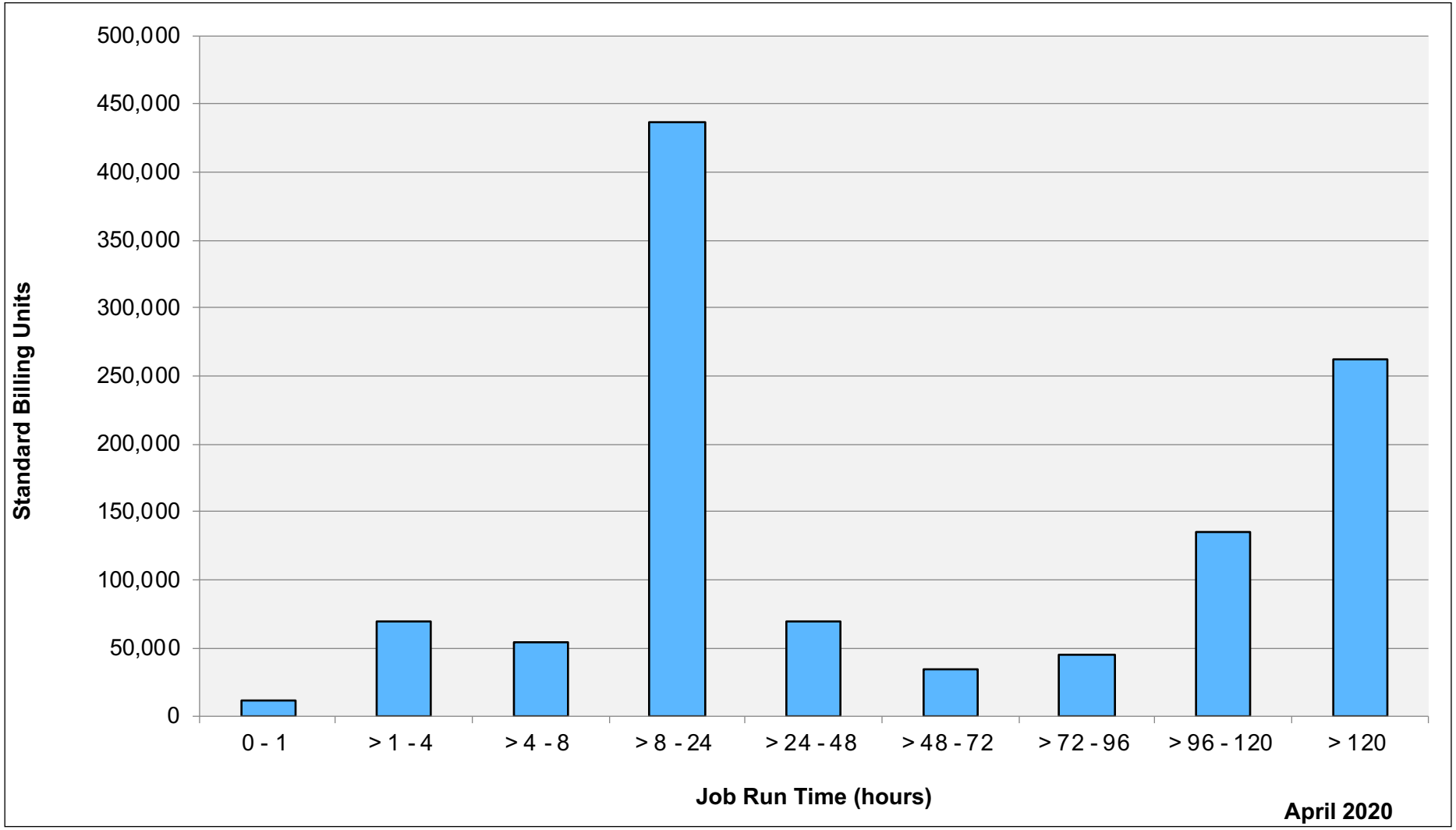

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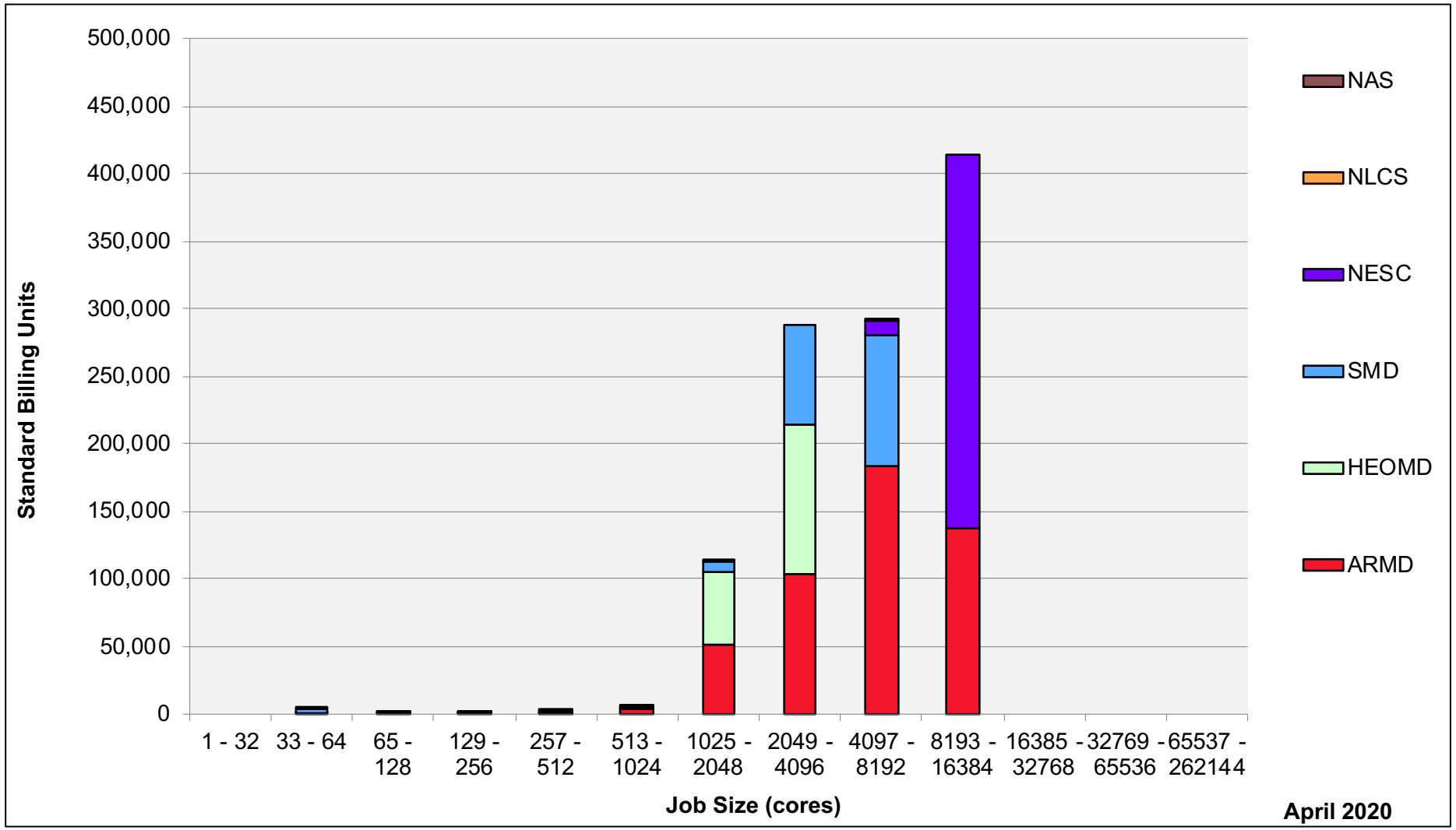
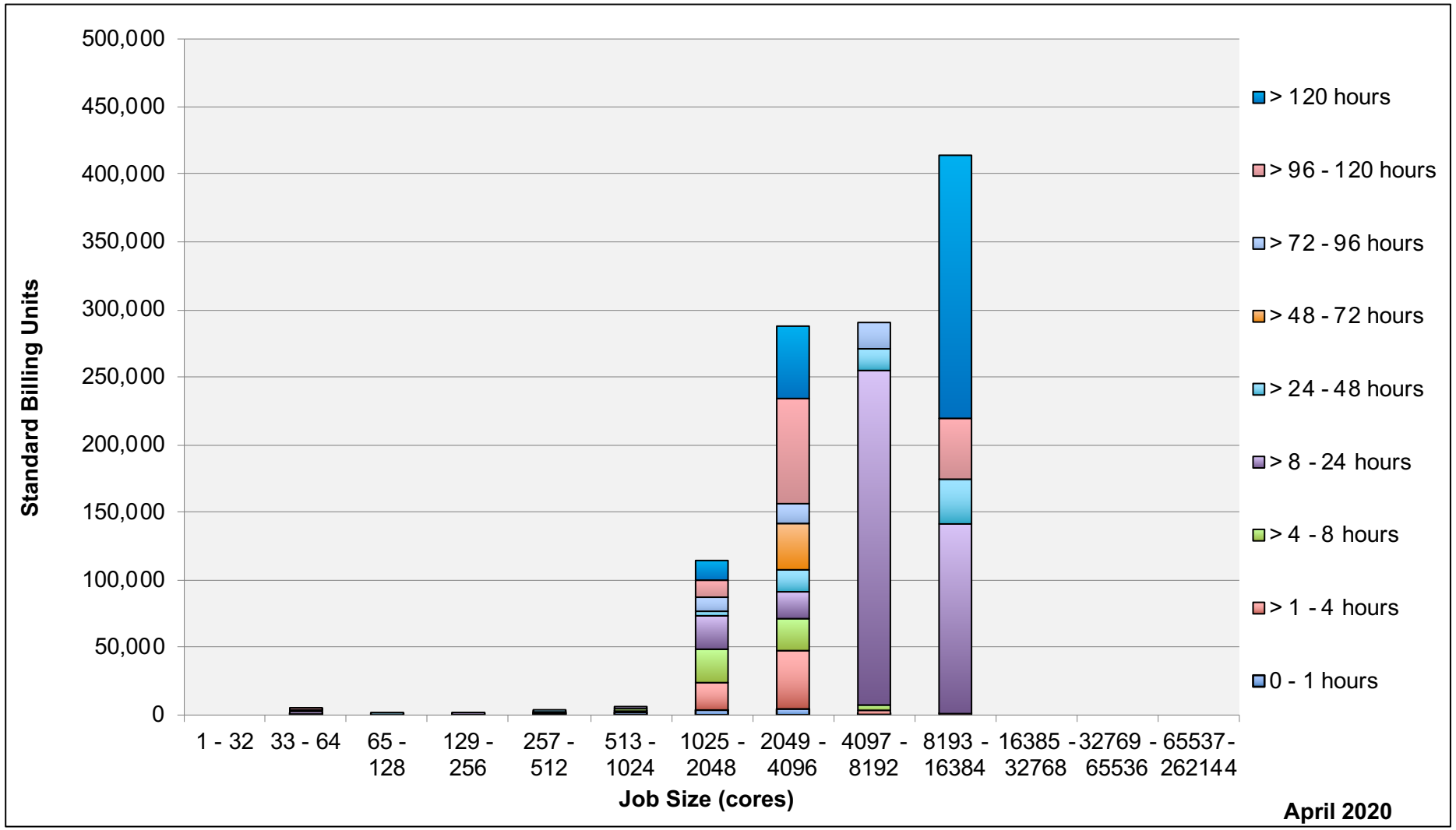
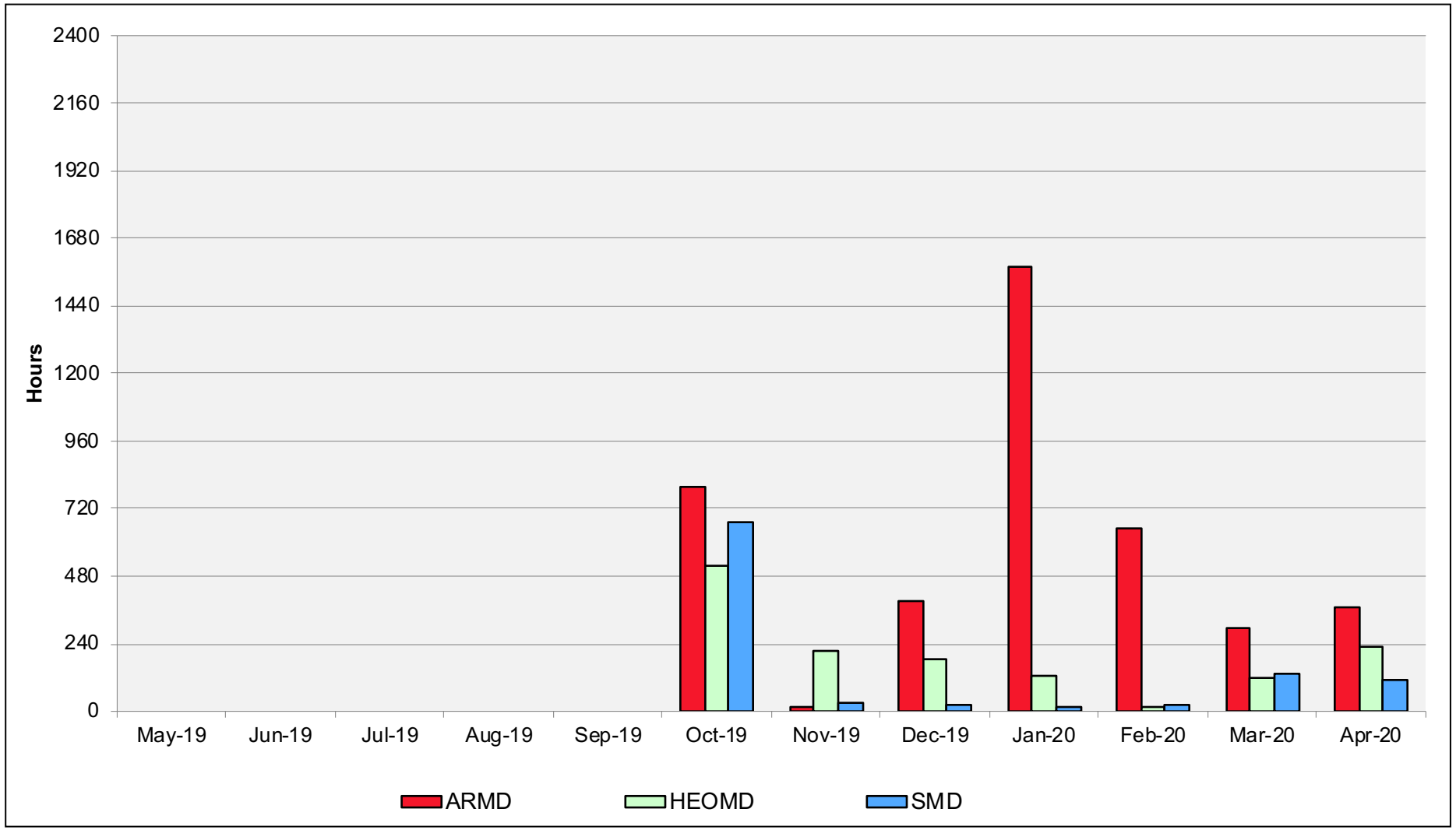


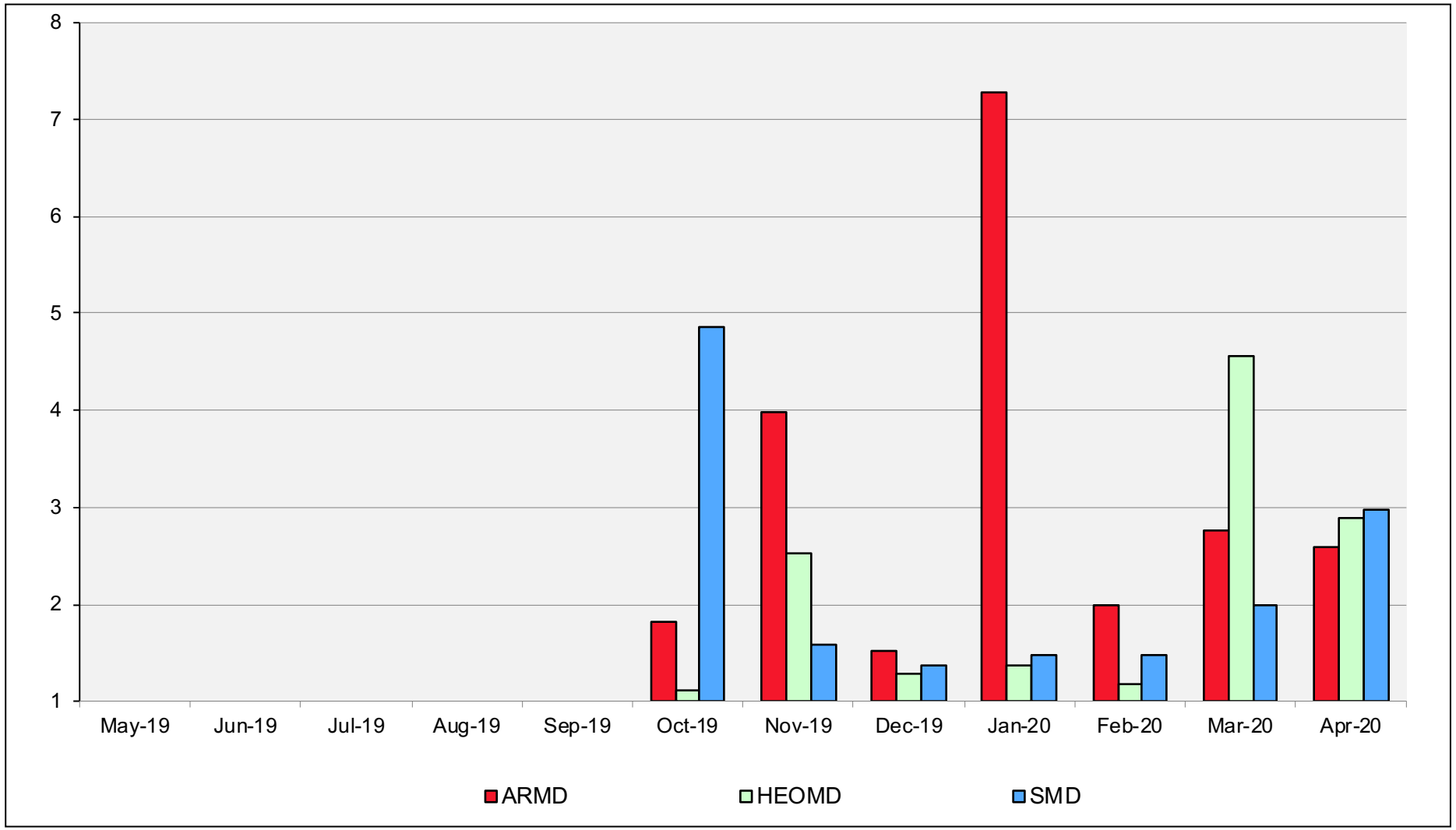
Aitken: Monthly Utilization by Size and Length



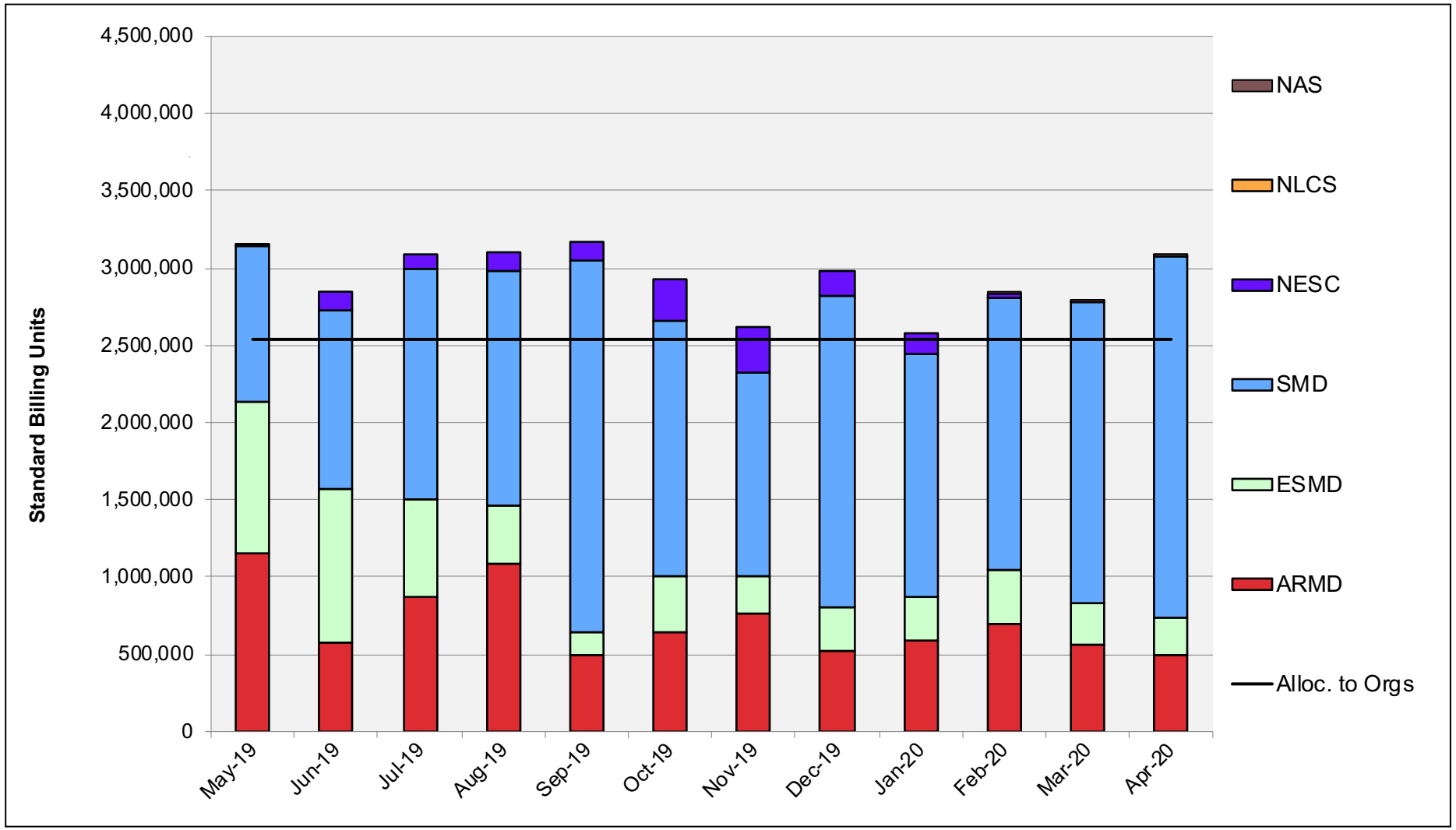
Aitken: Average Time to Clear All Jobs



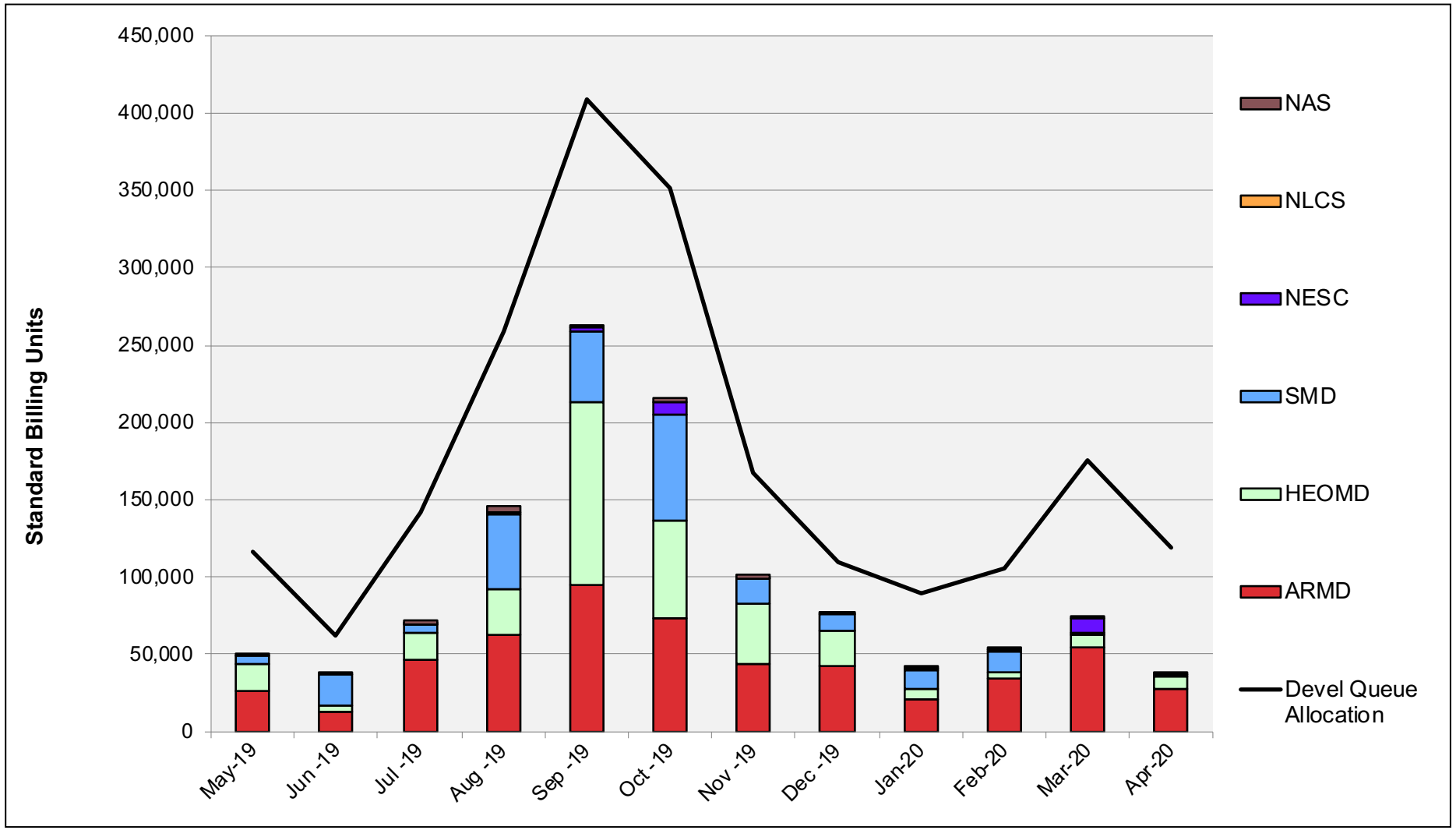
Aitken: Average Expansion Factor



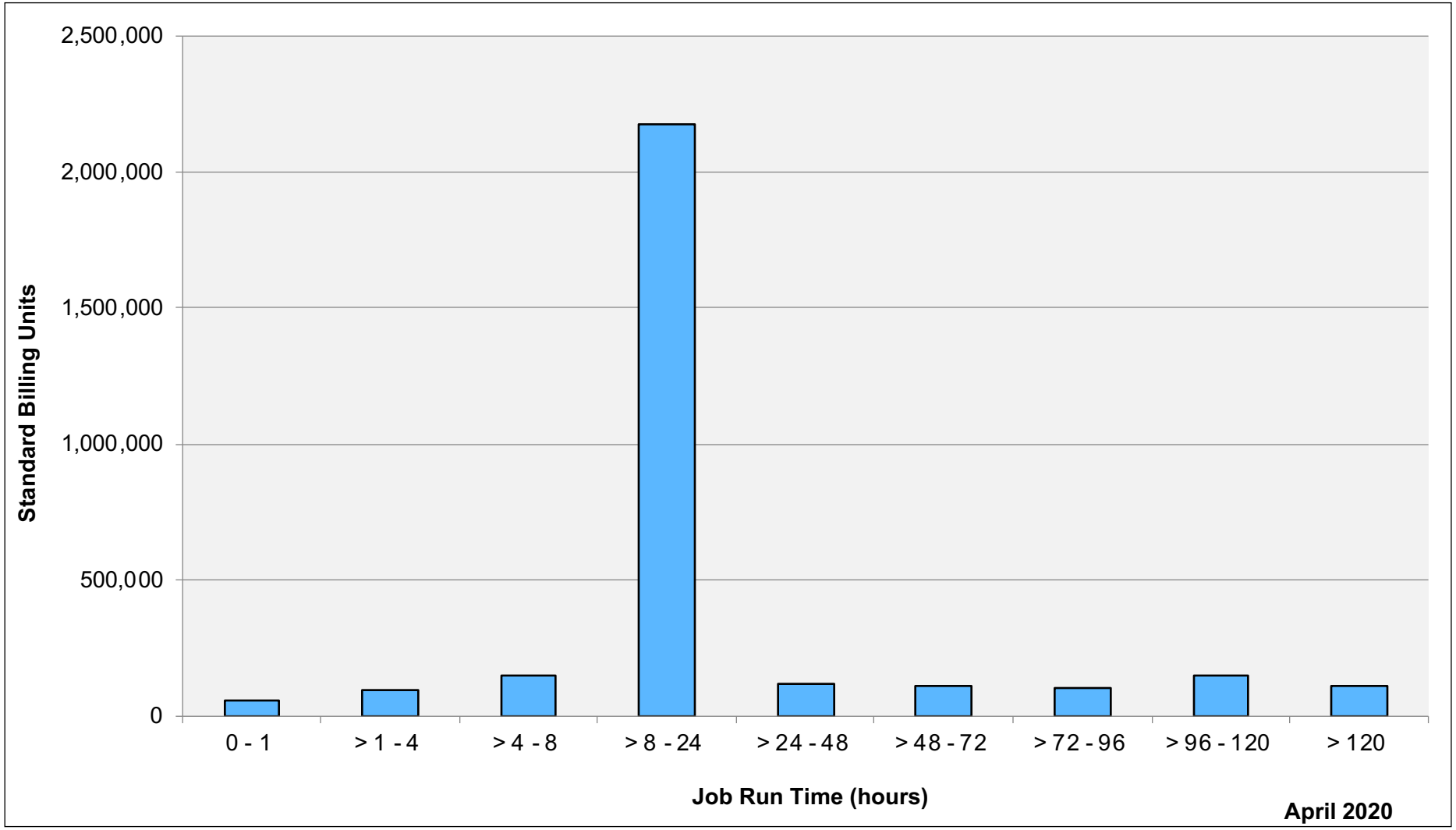
Electra: SBUs Reported, Normalized to 30-Day Month



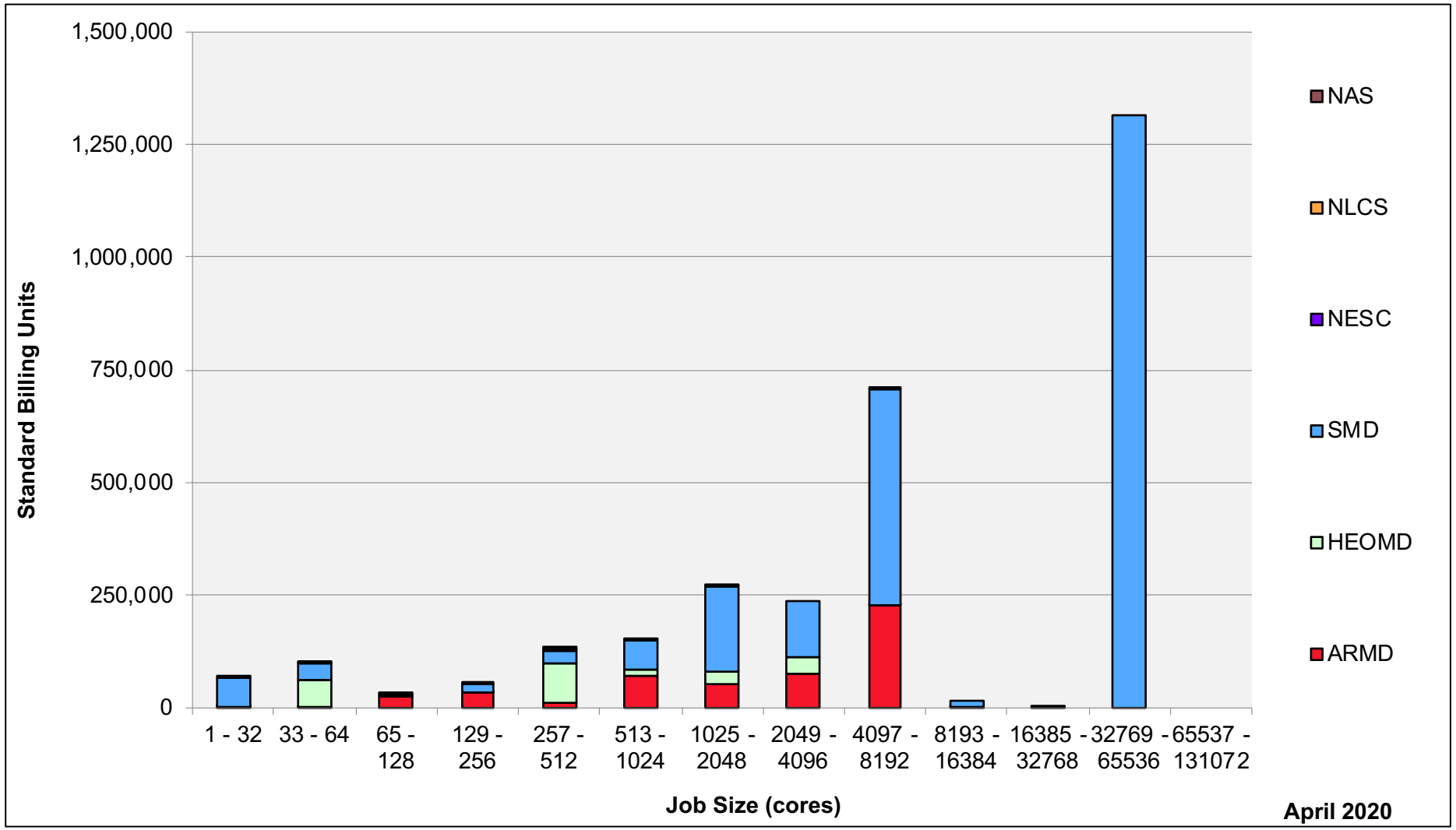
Electra: Devel Queue Utilization



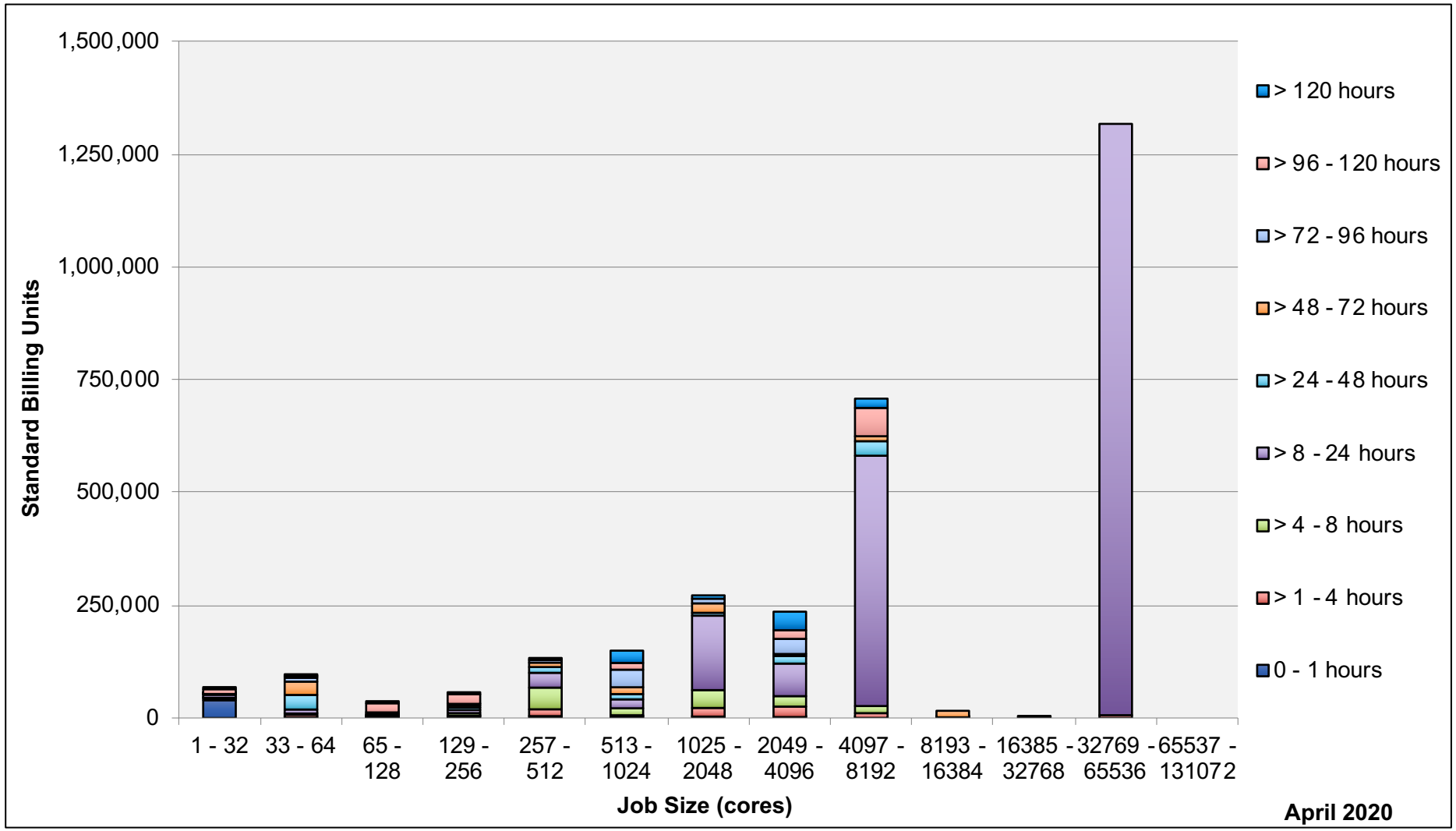
Electra: Monthly Utilization by Job Length



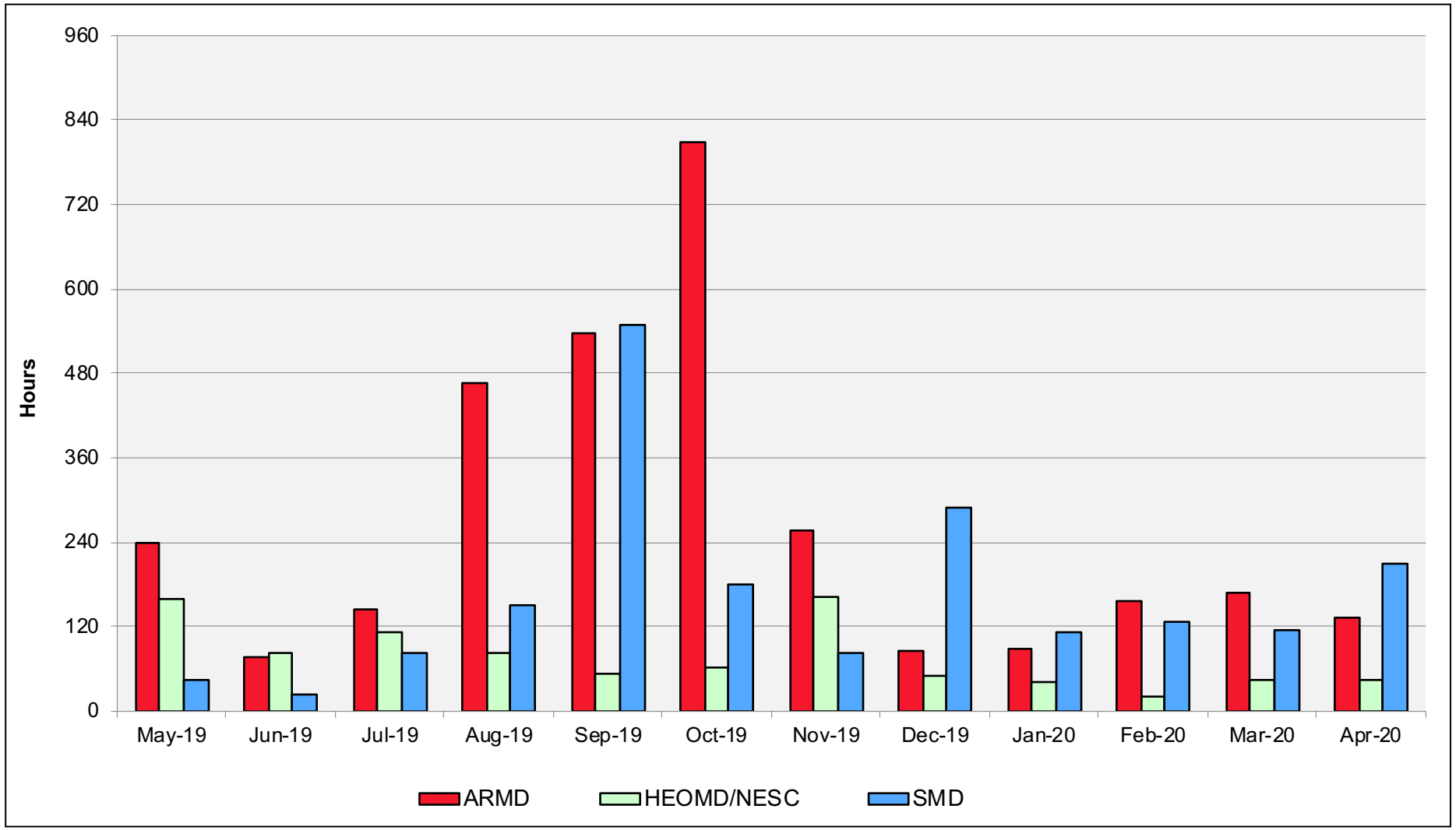
Electra: Monthly Utilization by Job Length



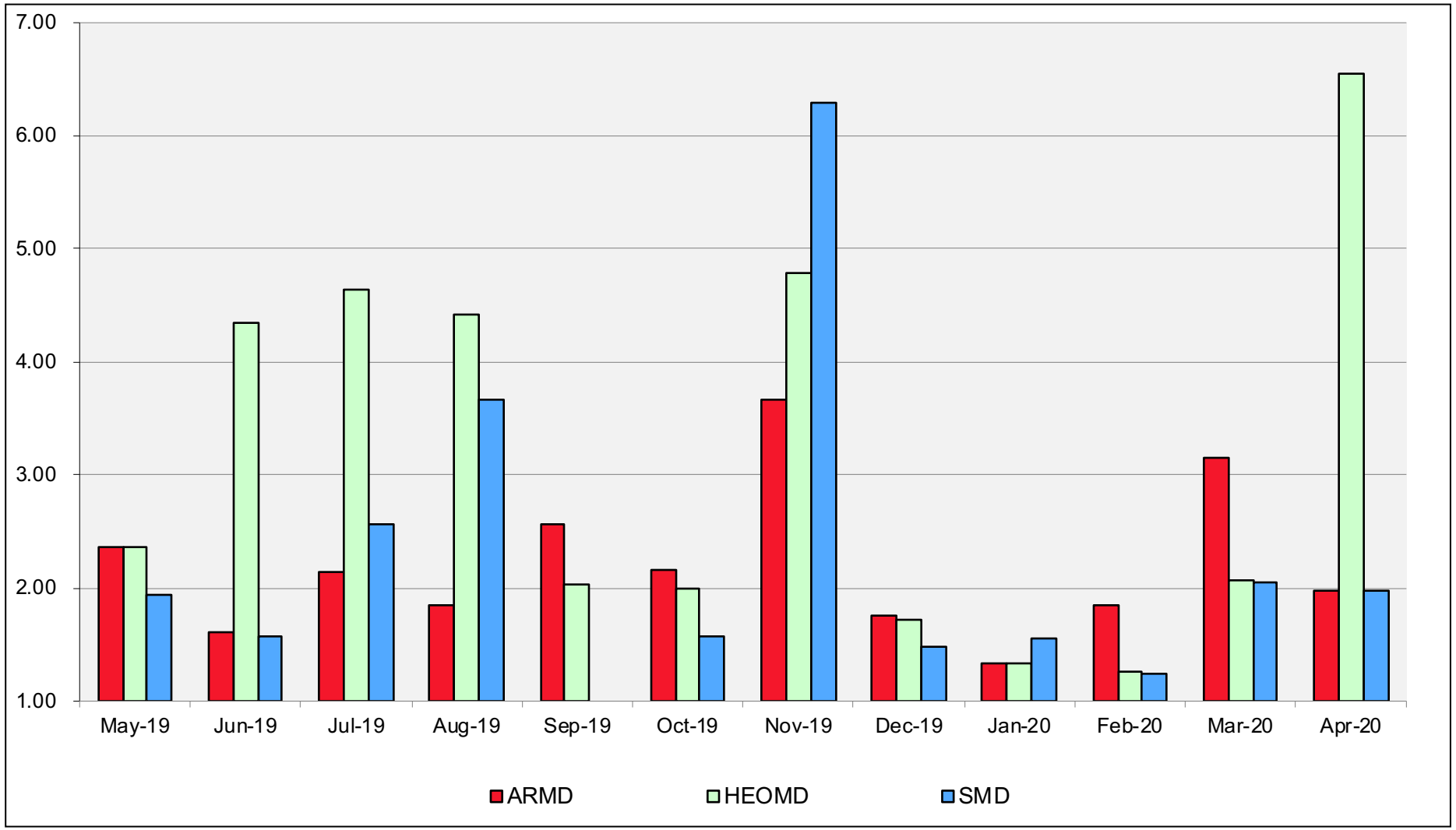
Electra: Monthly Utilization by Size and Length



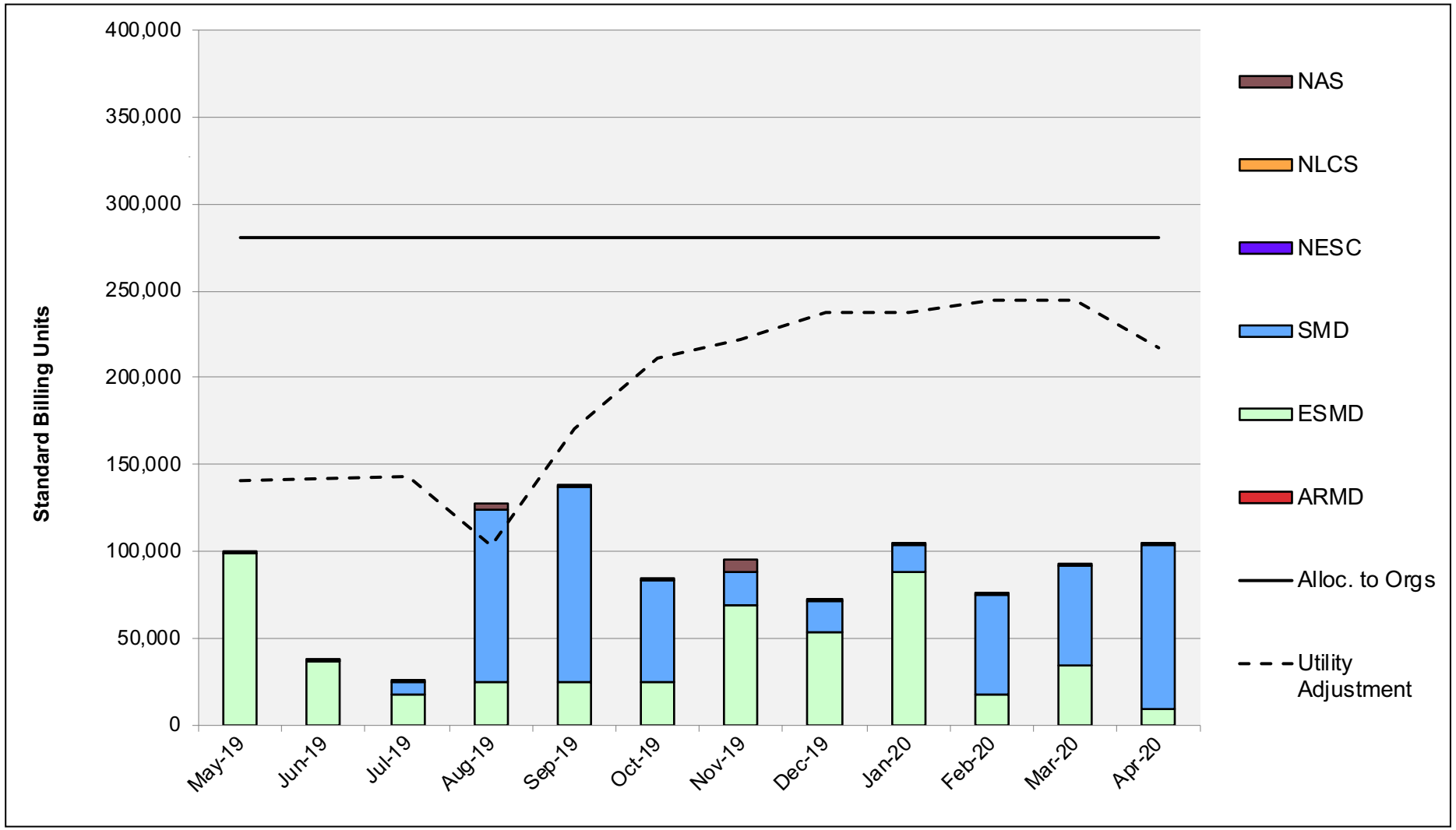
Electra: Average Time to Clear All Jobs



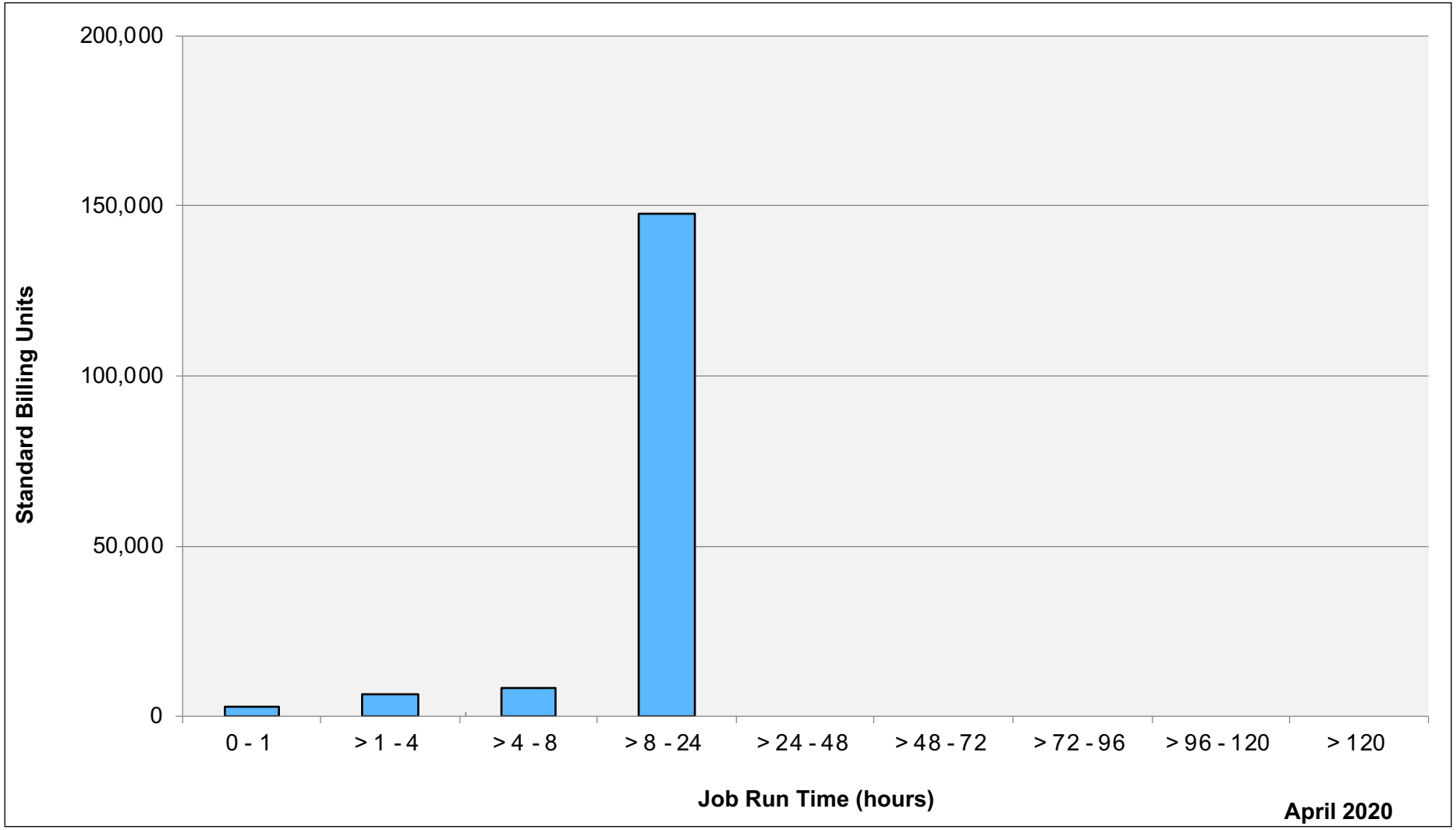
Electra: Average Expansion Factor



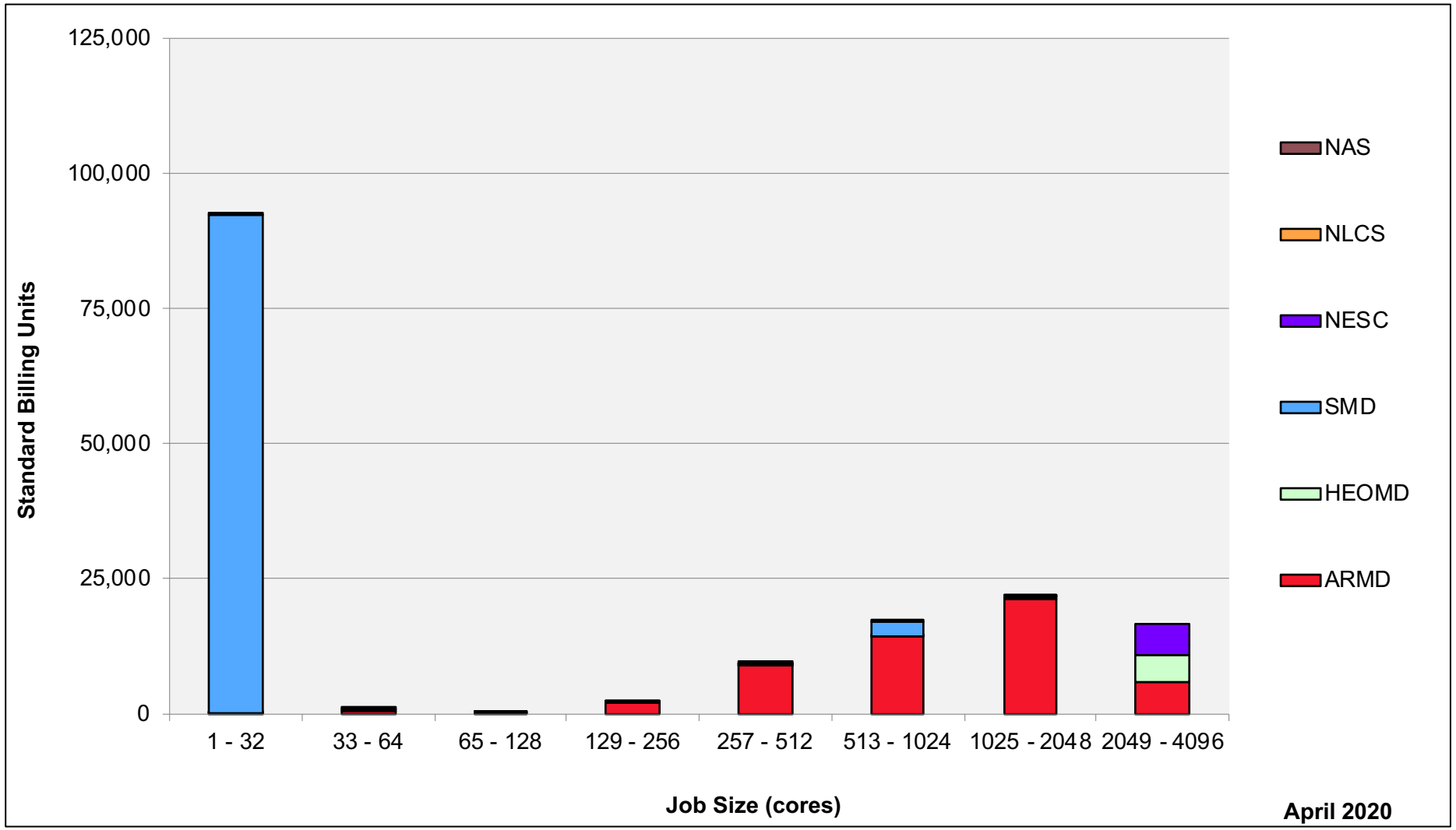
Merope: SBUs Reported, Normalized to 30-Day Month



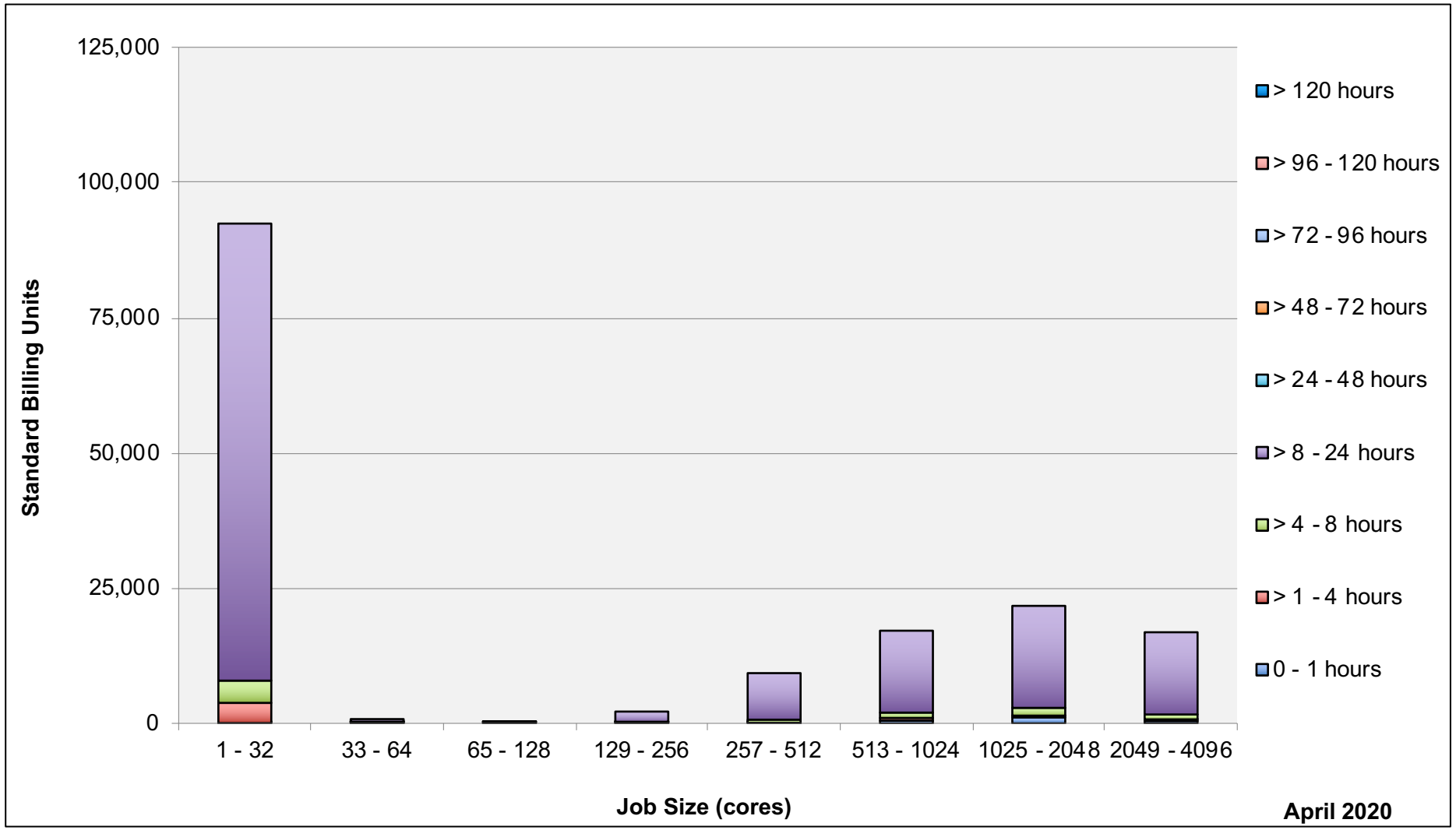
Merope: Monthly Utilization by Job Length



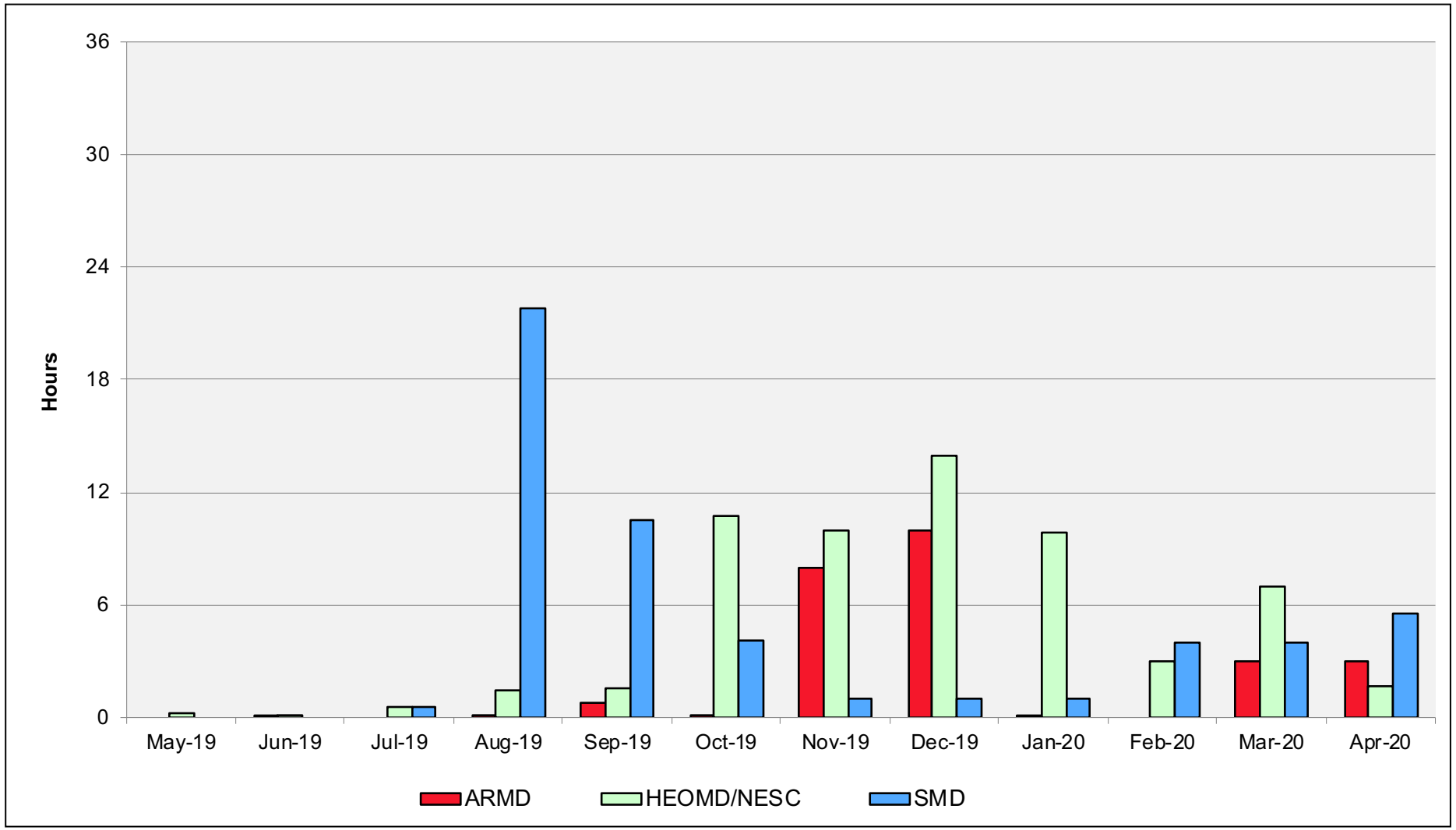
Merope: Monthly Utilization by Job Length



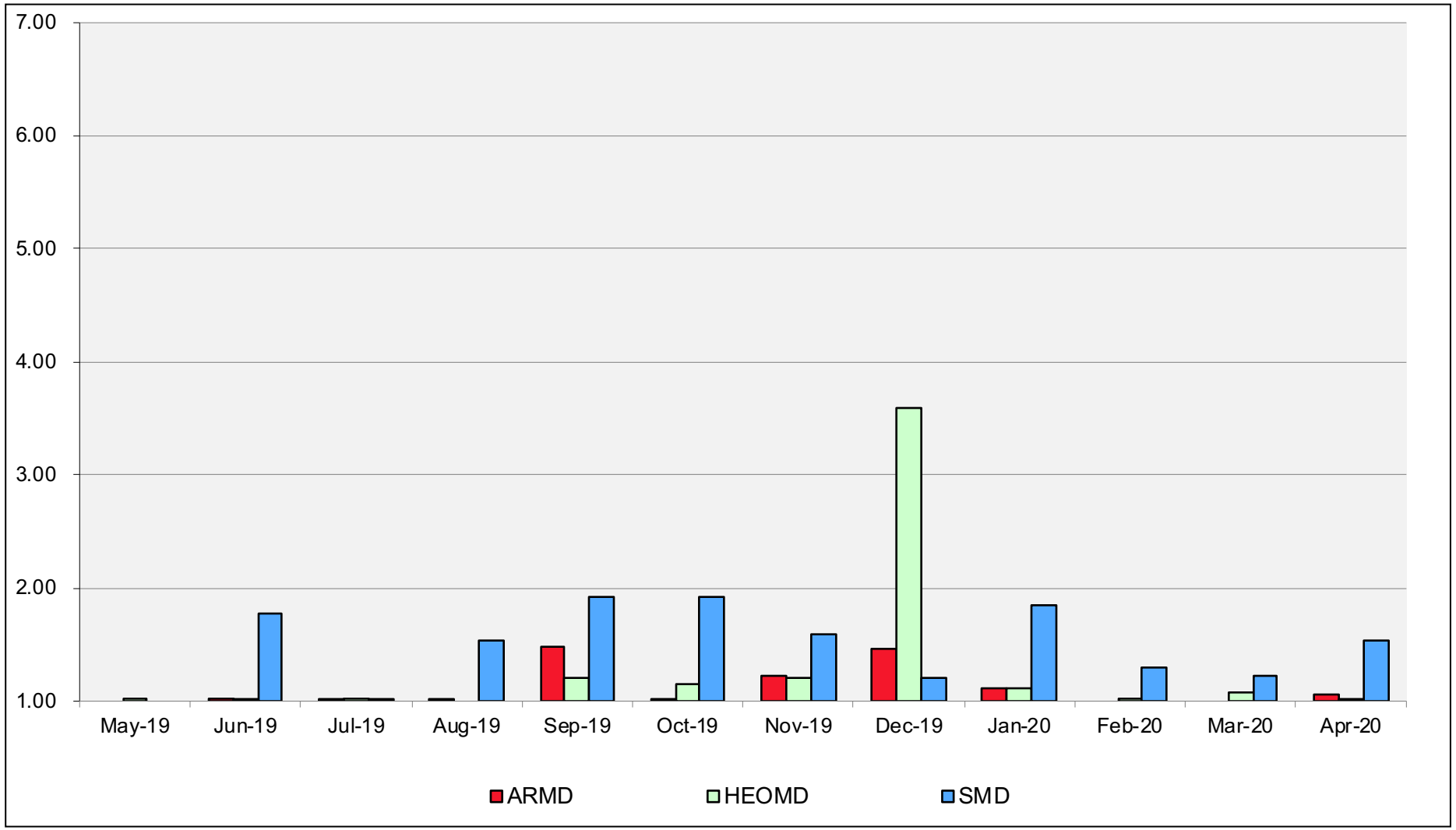
Merope: Monthly Utilization by Size and Length



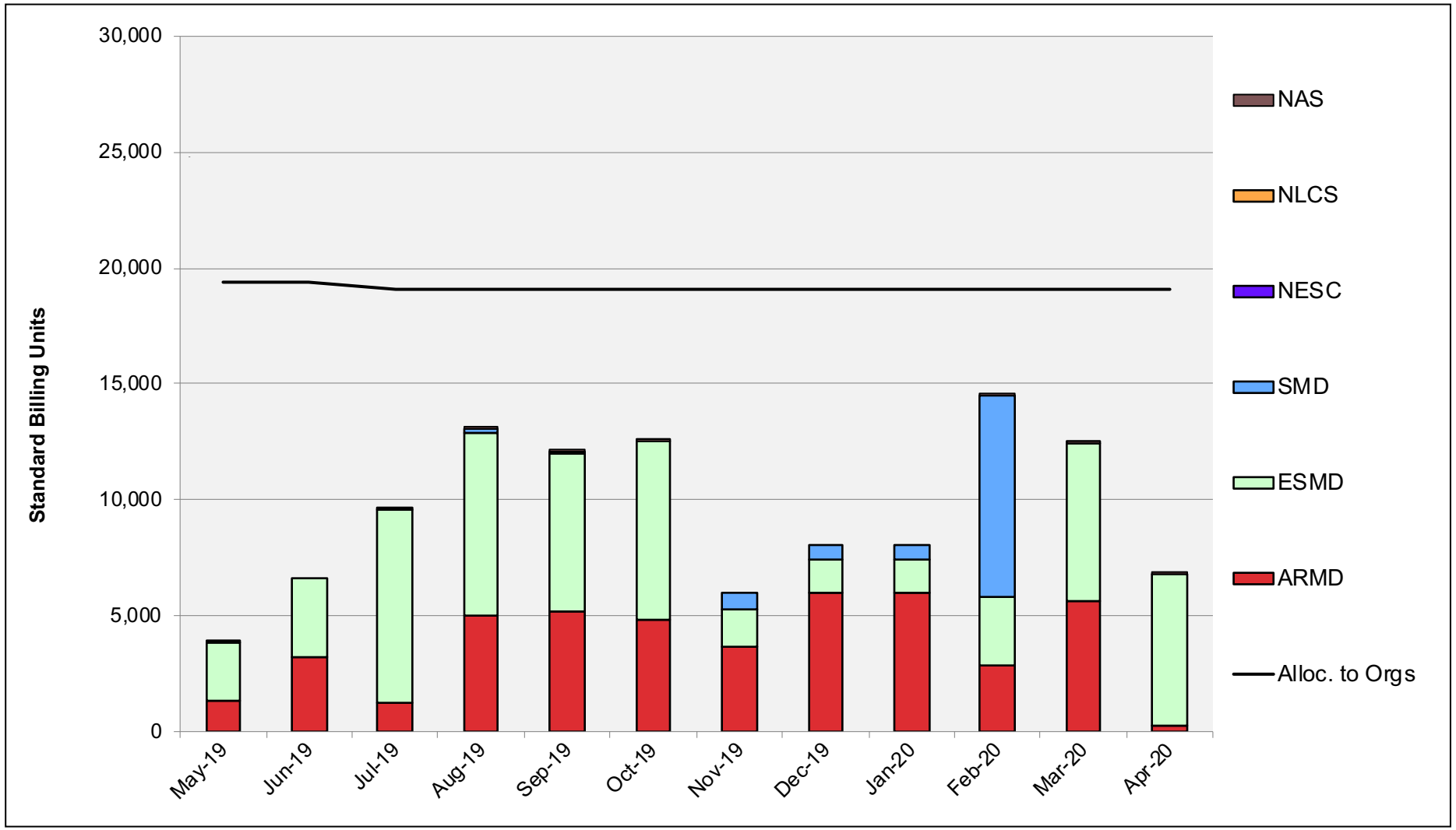
Merope: Average Time to Clear All Jobs



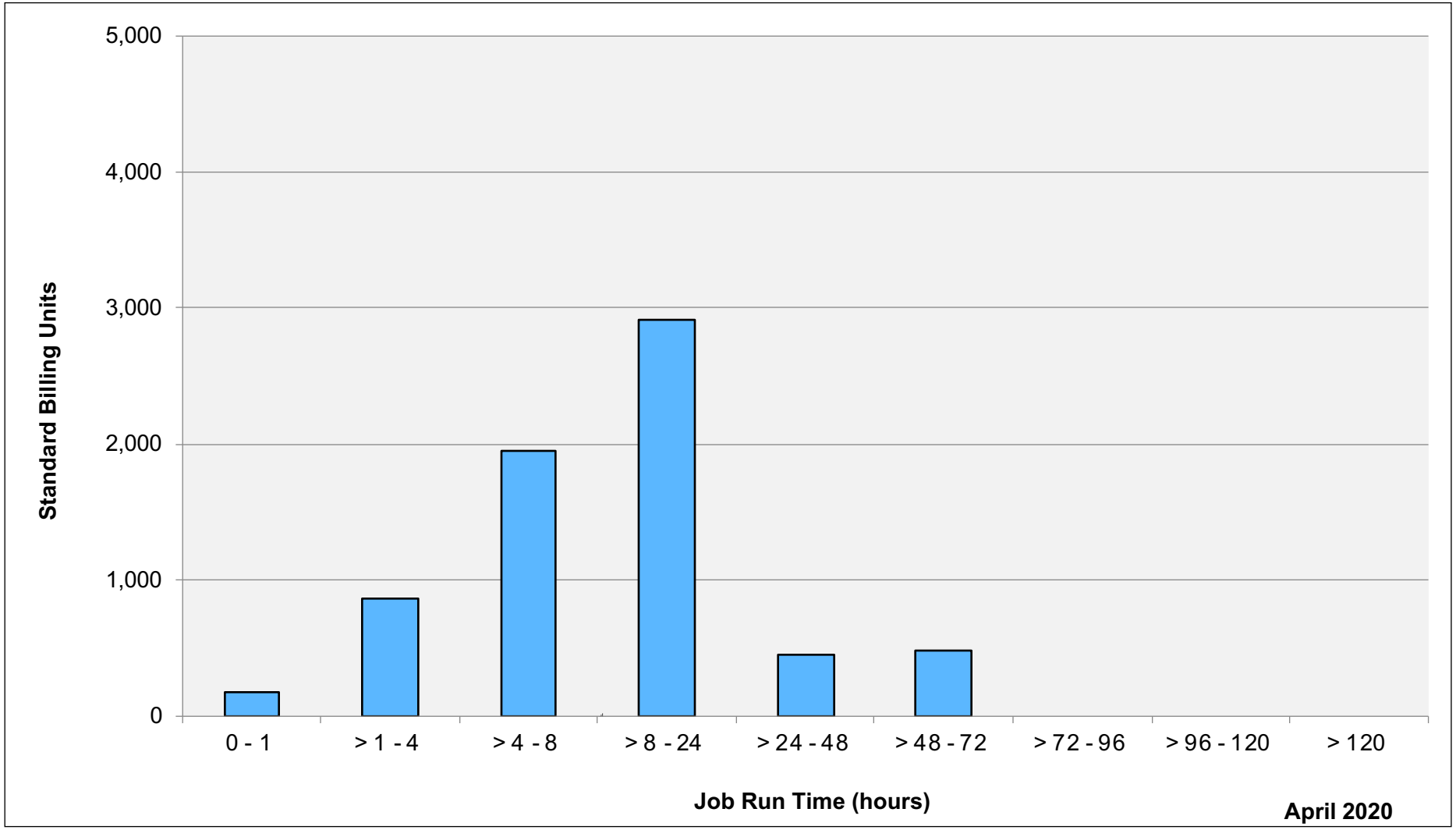
Merope: Average Expansion Factor



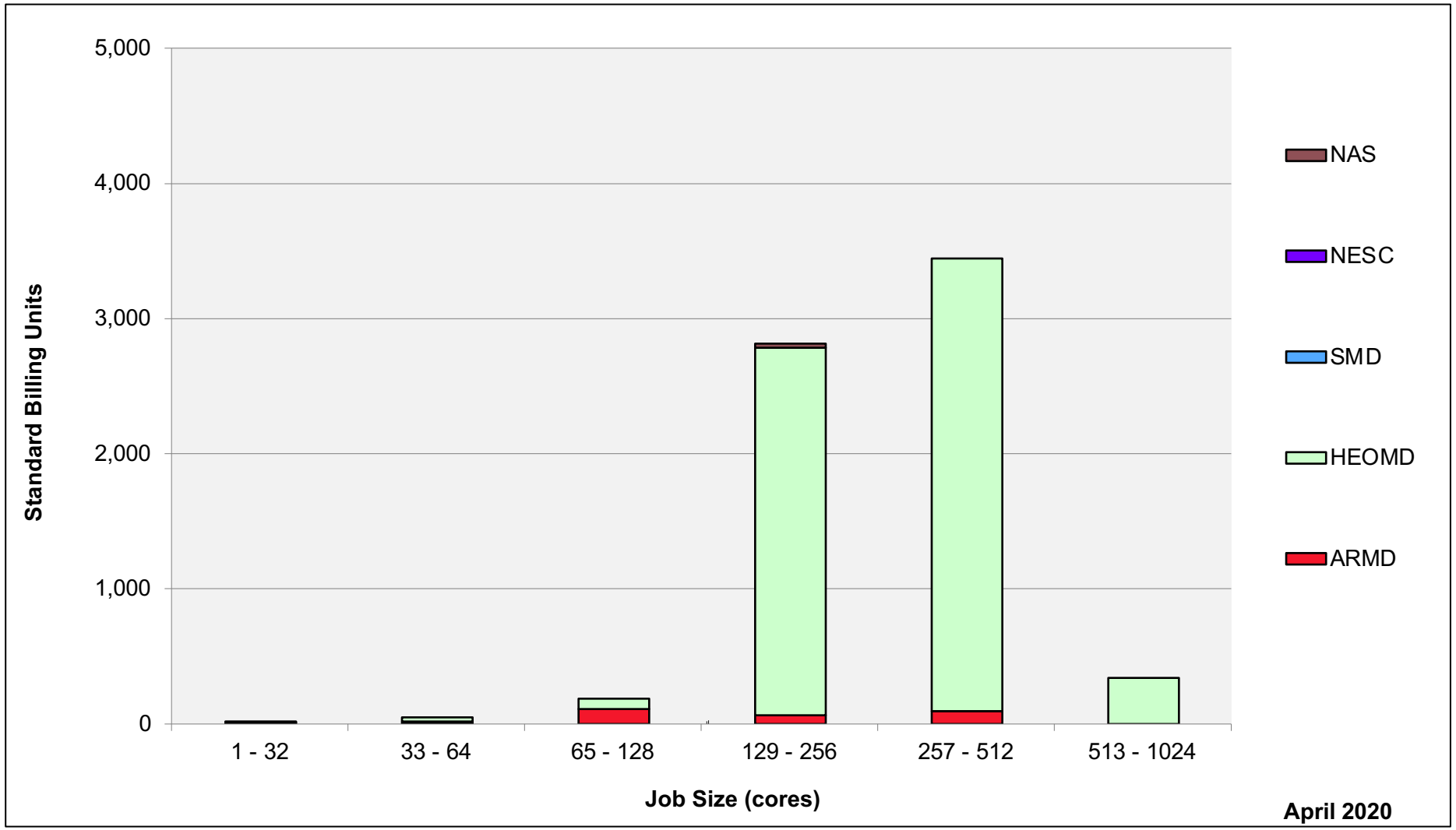
Endeavour: SBUs Reported, Normalized to 30-Day Month



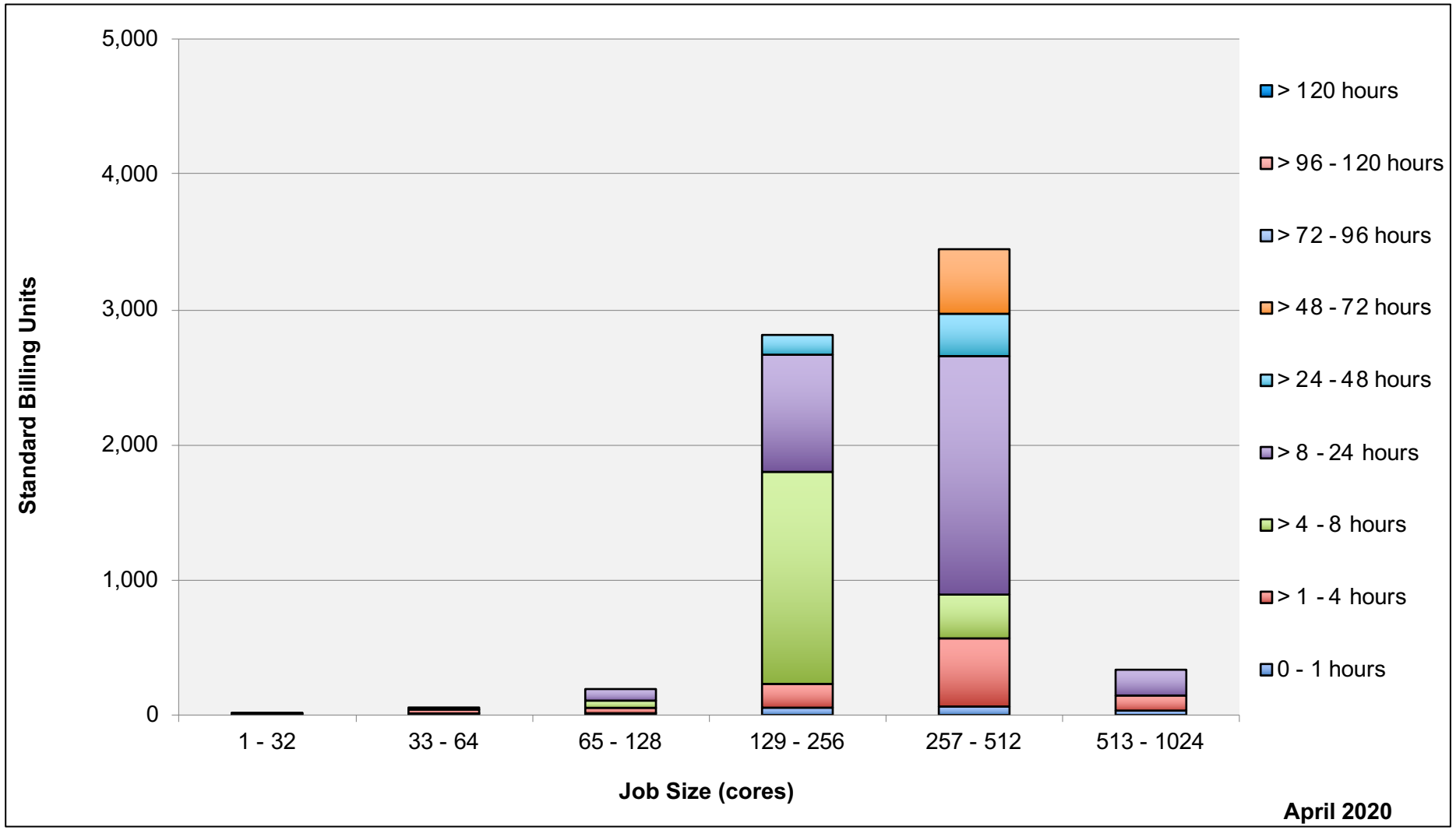
Endeavour: Monthly Utilization by Job Length



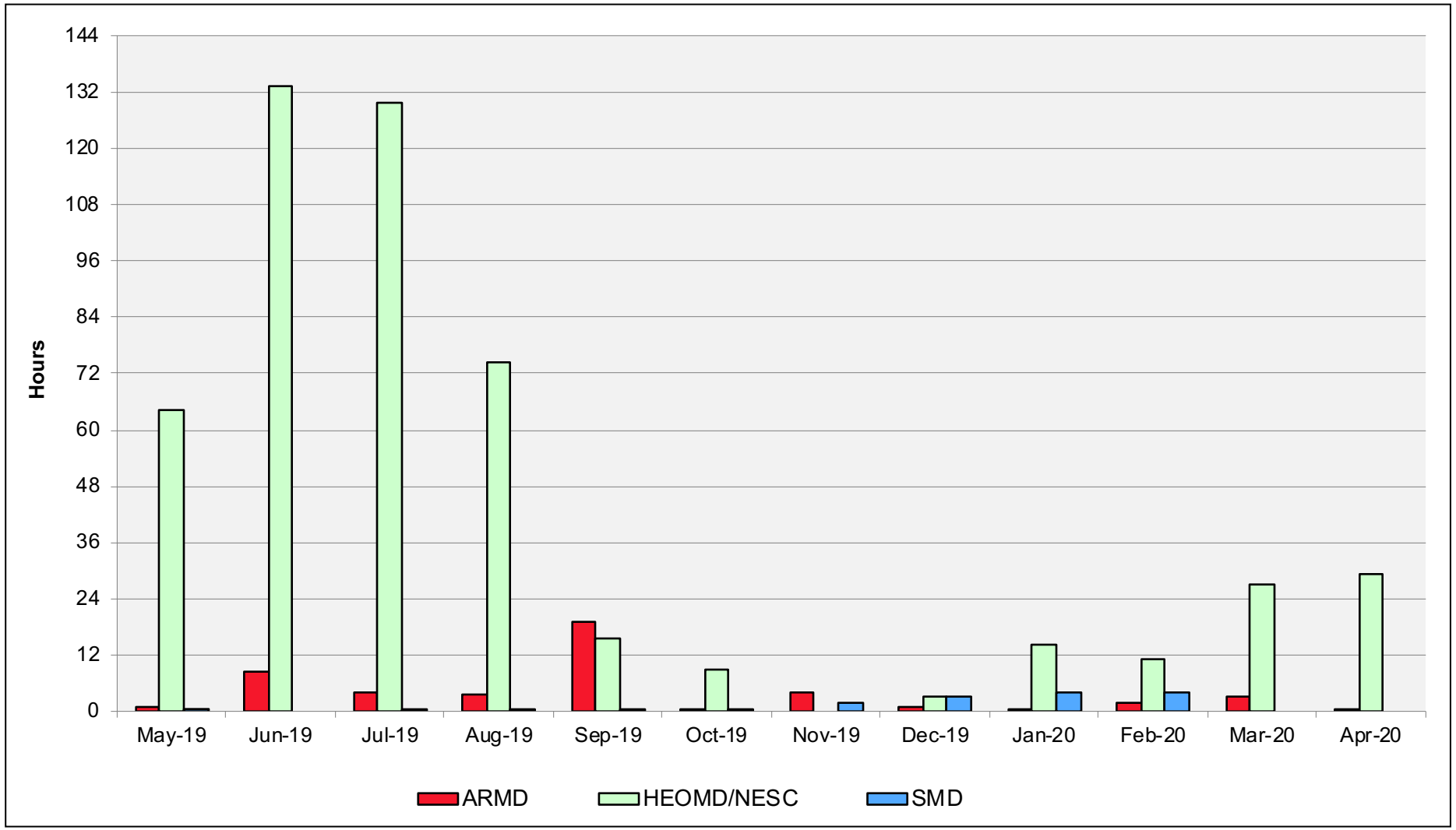
Endeavour: Monthly Utilization by Job Length



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Time to Clear All Jobs



Endeavour: Average Expansion Factor